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DEPARTMENT OF TRANSPORTATION
COMMONWEALTH OF PENNSYLVANIA

TRANSMITTAL LETTER

Pub. #19

DATE
July 4, 1977

SUBJECT:

Field Test Manual, July 1977 Edition

INFORMATION AND SPECIAL INSTRUCTIONS:

In addition to all the revisions to the September 1974 edition, this new edition also includes PTM #210 covering the test method for "Sampling and Testing Treated Wood Products".

PTR
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1977

CANCEL AND DESTROY THE FOLLOWING:

All editions of this Manual dated prior to July 1977.

REQUEST ADDITIONAL COPIES FROM:

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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
HARRISBURG, PA.

FIELD TEST MANUAL

PDT Pub. 19

JULY 1977
Edition

PREFACE

This manual has been prepared for the field engineering and inspection personnel to furnish them with detailed information on field testing and sampling. The majority of the methods were based on Department experience and practices. References were made where the methods were covered by either ASTM or AASHO Standard Methods. It was necessary to modify most of the methods to ensure uniformity of procedures and equipment and to promote expediency under field conditions. Modifications were in the form of additional information or requirements and should not change the final results.

This Testing Manual is designed for future additions and modifications. As new testing techniques are developed through our research efforts and become accepted by the Department, they will be incorporated into this manual. Corrections or amendments will be distributed by Office Services.

Your comments or suggestions toward the improvement of this manual will be appreciated. Any discrepancies or matters of major importance should be brought to the attention of the Director, Bureau of Materials, Testing and Research in writing.

This manual is not intended to modify Department standards, plans, specifications or contracts. These methods, however, supersede all previous methods that are within the scope of this manual.

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Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 1
August 1973
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

PROBABILITY SAMPLING

1. Scope

1.1 This method of test outlines the procedures for selecting sampling sites in accordance with accepted probability sampling techniques. It is intended that all Department samples, regardless of size, type or purpose shall be selected in an unbiased manner, based entirely on chance.

2. Securing Samples

2.1 Department samples shall be taken by the engineer or his authorized representative.

2.2 The use of a table of random numbers for selection of a sampling site is mandatory.

2.3 Sample location and sampling procedure are as important as testing. It is essential that the sample location be chosen in an unbiased manner and the sample taken precisely as directed by the appropriate PTM.

3. Random Number Table

3.1 For test results or measurements to be meaningful, it is necessary that the SUBLOTS to be sampled or measured be selected at random, which means using a table of random numbers. The following table of random numbers has been devised for this purpose. To use the table in selecting sample locations, proceed as follows:

3.2 Determine the LOT size and the number of SUBLOTS per LOT by referring to the PTM for the material being sampled.

3.3 For samples taken from the roadway, use the decimal values in Column X and Column Y to determine the coordinates of the sample locations as specified in the appropriate PTM.

3.4 In situations where coordinate locations do not apply (i.e., plant mix samples, stockpile samples, etc.), use only those decimal values from Column X or Column Y as specified in the appropriate PTM.

3.5 Be sure to go completely through Table I before using the same number over. For example, if the PTM for a particular material specified 5 sublots per lot, use numbers 1-5 from Column X (or Column Y) for the first lot, numbers 6-10 for the second lot, 11-15 for the third lot, and so on. If more than 20 lots are involved, start over with numbers 1-5 for the 21st lot. The order of the numbered sample locations must be preserved.

4. Sampling Procedure

4.1 After the appropriate number of random locations have been determined, refer to the proper PTM for special sampling procedure instructions and examples.

5. Definition of Terms

5.1 Lot — an isolated quantity of a specified material from a single source or a measured amount of specified construction assumed to be produced by the same process. The lot size is specified in the PTM for the material being sampled.

5.2 Sublot — a portion of a lot; the actual location from which a sample is taken. The size of the sublot and the number of sublots per lot are specified in the PTM for the material being sampled.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

TABLE I

RANDOM POSITIONS IN DECIMAL FRACTIONS (4 PLACES)

	X	Y		X	Y
1.	0.4721	R 0.2091	51.	0.6985	L 0.8636
2.	0.6936	L 0.3182	52.	0.3410	L 0.5636
3.	0.6112	R 0.2909	53.	0.5937	R 0.3727
4.	0.7930	R 0.8908	54.	0.6912	R 0.4545
5.	0.0652	L 0.4818	55.	0.0318	R 0.7272
6.	0.4604	L 0.2091	56.	0.1303	R 0.8090
7.	0.0167	L 0.3727	57.	0.6893	R 1.0000
8.	0.0077	R 0.6181	58.	0.3886	R 0.7817
9.	0.6777	R 0.8636	59.	0.0312	R 0.8090
10.	0.8010	L 0.8362	60.	0.0166	R 0.5909
11.	0.3027	L 0.3454	61.	0.4609	L 0.4000
12.	0.9831	L 0.2364	62.	0.0893	L 0.9726
13.	0.7159	R 0.6181	63.	0.4542	L 0.1545
14.	0.3609	R 0.6454	64.	0.9363	R 0.1000
15.	0.8915	L 0.2636	65.	0.8183	R 0.5636
16.	0.6442	R 0.3182	66.	0.9401	L 0.5091
17.	0.1904	R 0.1818	67.	0.5967	L 0.9726
18.	0.6074	R 0.8908	68.	0.7547	R 0.2636
19.	0.7522	R 0.9181	69.	0.0101	R 0.2909
20.	0.7041	L 0.8362	70.	0.2896	L 0.8362
21.	0.5102	R 0.2364	71.	0.8011	R 0.6454
22.	0.2471	L 0.3182	72.	0.6718	L 0.6454
23.	0.5693	L 0.5636	73.	0.5567	L 0.1818
24.	0.8583	R 0.4545	74.	0.0481	L 0.2636
25.	0.3093	R 0.1818	75.	0.4266	L 0.9454
26.	0.9144	R 0.9181	76.	0.3941	R 0.5636
27.	0.7944	L 0.5909	77.	0.9876	L 0.7545
28.	0.8725	R 0.2636	78.	0.6313	R 0.7272
29.	0.0135	R 0.8908	79.	0.6803	R 0.3182
30.	0.2044	R 0.7272	80.	0.7955	L 0.9726
31.	0.2517	L 0.2909	81.	0.7399	R 0.8080
32.	0.2763	L 0.8090	82.	0.9328	L 0.5909
33.	0.0314	R 0.4818	83.	0.1507	L 0.4000
34.	0.9560	L 1.0000	84.	0.3087	R 0.3182
35.	0.4622	R 0.4000	85.	0.7513	L 0.1818
36.	0.1327	L 0.7817	86.	0.6469	R 0.4818
37.	0.6922	L 0.5636	87.	0.2536	R 0.7545
38.	0.0010	L 0.1273	88.	0.1488	R 0.1818
39.	0.7609	R 0.2091	89.	0.9411	L 0.5636
40.	0.5957	L 0.1000	90.	0.0571	R 1.0000
41.	0.3115	L 0.4000	91.	0.4797	R 0.9454
42.	0.3377	R 0.8362	92.	0.0866	R 0.4272
43.	0.5651	L 0.1545	93.	0.2889	R 0.1273
44.	0.4742	R 0.6727	94.	0.4783	L 0.7000
45.	0.9483	L 0.4000	95.	0.0304	R 0.9181
46.	0.2951	R 0.6451	96.	0.8945	R 0.4515
47.	0.0441	L 0.1273	97.	0.4499	R 0.2081
48.	0.9143	L 0.1273	98.	0.9205	L 0.9454
49.	0.5723	L 0.8362	99.	0.5827	L 0.5636
50.	0.6069	R 0.4000	100.	0.4560	L 0.8908

X = Decimal fraction of total length measured along the road from starting point.

Y = Decimal fraction of half width measured across the road from outside edge towards centerline.

R = Indicates measurement from right edge.

L = Indicates measurement from left edge.

TABLE II
RANDOM POSITIONS IN DECIMAL FRACTIONS (2 PLACES)

X	Y	X	Y
1. 0.47	R 0.20	51. 0.69	L 0.86
2. 0.69	L 0.31	52. 0.34	L 0.56
3. 0.61	R 0.29	53. 0.59	R 0.37
4. 0.79	R 0.89	54. 0.69	R 0.45
5. 0.06	L 0.48	55. 0.03	R 0.72
6. 0.46	L 0.20	56. 0.13	R 0.80
7. 0.01	L 0.37	57. 0.68	R 1.00
8. 0.00	R 0.61	58. 0.38	R 0.78
9. 0.67	R 0.86	59. 0.03	R 0.80
10. 0.80	L 0.83	60. 0.01	R 0.59
11. 0.30	L 0.34	61. 0.46	L 0.40
12. 0.98	L 0.23	62. 0.08	L 0.97
13. 0.71	R 0.61	63. 0.45	L 0.15
14. 0.36	R 0.64	64. 0.93	R 0.10
15. 0.89	L 0.26	65. 0.81	R 0.56
16. 0.64	R 0.31	66. 0.94	L 0.50
17. 0.19	R 0.18	67. 0.59	L 0.97
18. 0.60	R 0.89	68. 0.75	R 0.26
19. 0.75	R 0.91	69. 0.01	R 0.29
20. 0.70	L 0.83	70. 0.28	L 0.83
21. 0.51	R 0.23	71. 0.80	R 0.64
22. 0.24	L 0.31	72. 0.67	L 0.64
23. 0.56	L 0.56	73. 0.55	L 0.18
24. 0.85	R 0.45	74. 0.04	L 0.26
25. 0.30	R 0.18	75. 0.42	L 0.94
26. 0.91	R 0.91	76. 0.39	R 0.56
27. 0.79	L 0.59	77. 0.98	L 0.75
28. 0.87	R 0.26	78. 0.63	R 0.72
29. 0.01	R 0.89	79. 0.68	R 0.31
30. 0.20	R 0.72	80. 0.79	L 0.97
31. 0.25	L 0.29	81. 0.73	R 0.80
32. 0.27	L 0.80	82. 0.93	L 0.59
33. 0.03	R 0.48	83. 0.15	L 0.40
34. 0.95	L 1.00	84. 0.30	R 0.31
35. 0.46	R 0.40	85. 0.75	L 0.18
36. 0.13	L 0.78	86. 0.64	R 0.48
37. 0.69	L 0.56	87. 0.25	R 0.75
38. 0.00	L 0.12	88. 0.14	R 0.18
39. 0.76	R 0.20	89. 0.94	L 0.56
40. 0.59	L 0.10	90. 0.05	R 1.00
41. 0.31	L 0.40	91. 0.47	R 0.94
42. 0.33	R 0.83	92. 0.08	R 0.42
43. 0.56	L 0.15	93. 0.28	R 0.12
44. 0.47	R 0.67	94. 0.47	L 0.70
45. 0.94	L 0.40	95. 0.03	R 0.91
46. 0.29	R 0.64	96. 0.89	R 0.45
47. 0.04	L 0.12	97. 0.44	R 0.20
48. 0.91	L 0.12	98. 0.92	L 0.84
49. 0.57	L 0.83	99. 0.58	L 0.56
50. 0.60	R 0.40	100. 0.45	L 0.89

X = Decimal fraction of total length measured along the road from starting point.
Y = Decimal fraction of half width measured across the road from outside edge towards centerline.
R = Indicates measurement from right edge.
L = Indicates measurement from left edge.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 2
February 1976
2 Pages

Definition of Terms and Requirements for Laboratory Weights and Balances

1. Scope

1.1 These definitions cover the terms and requirements which are included in the standard specifications for weights and balances used in the testing of highway materials (Reference: AASHTO Designation: M 231).

2. Definitions

2.1 Definitions applicable to weights are as follows:

2.1.1 Analytical Weights — Weights used for analytical work.

2.1.2 General Purpose Weights — Weights used for general laboratory weighings.

2.2 Definitions applicable to balances are as follows:

2.2.1 Readability — The smallest fraction of a division at which the index scale can be read with ease either by estimation or by use of a vernier on a direct-reading balance.

2.2.2 Sensitivity — Ability of a balance to respond to an applied load at any test point within the rated capacity.

2.2.3 Accuracy — Conformance of the indications or deliveries of a balance within applicable tolerances as determined by tests made with suitable standards.

2.2.4 Simple Balance — A balance designed primarily for use in conjunction with a set of weights. There may or may not be a weighbeam.

2.2.5 Direct Reading Balance — A balance on which the weights of applied loads of various magnitudes are either automatically indicated throughout all or a portion of the weighing range of the balance measured by means of a weighbeam.

2.2.6 Weighbeam — An element comprising one or more bars, equipped with movable poises or means for applying counterpoise weights or both.

3. Classifications of Balances and Weights

3.1 Balances — Types and classes of balances are defined in Table 1.

3.2 Weights —

3.2.1 Analytical Weights — Analytical weights that conform to Class S-1 requirements as described in National Bureau of Standards Handbook 77, Part III, and their applicable tolerances are shown in the following Table 2.

3.2.2 General Purpose Weights — General purpose weights that conform to the requirements for metric weights as described in the 3rd edition of National Bureau of Standards Handbook 44 and their applicable tolerances are shown in the following Table 3.

Table 1
Classification of Balances

	Type 1 Simple Balances		Type 2 Direct Reading Balances			
Class	Sensitivity	Accuracy	Readability	Sensitivity	Accuracy	Recommended Maximum Range of use
A	0.0001 g	0.0002 g	0.0001 g	0.0001 g	0.0002 g	200 g (1)
B	0.001 g	0.002 g	0.001 g	0.001 g	0.002 g	200 g (1)
C	0.01 g	0.02 g	0.01 g	0.01 g	0.02 g	1200 g (1)
D	0.1 g	0.2 g	0.1 g	0.1 g	0.2 g	2000 g (1)
E	0.5 g	1.0 g	1.0 g	0.5 g	1.0 g	5000 g (1)
F	5.0 g	0.2% *	5.0 g	5.0 g	0.2% *	— — (1)

*0.2 percent of total sample weight

(1) or maximum range of use as recommended by manufacturer.

TABLE 2

Tolerances on Analytical Weights

	Tolerances on Weights in Use, plus or minus, mg*
Grams	
100	1.0
50	0.6
30	0.45
20	0.35
10	0.25
5	0.18
2	0.13
1	0.10
Milligrams	
500	0.080
300	0.070
200	0.060
100	0.050
50	0.042
30	0.038
20	0.035
10	0.030

*Two-thirds of the weights in a new set must be within one-half the individual tolerances.

TABLE 3

Tolerances on General Purpose Weights

	Tolerances on Weights in Use, plus or minus, g*
2000	0.40
1000	0.25
500	0.20
300	0.15
200	0.10
100	0.07
50	0.04
30	0.03
20	0.02
10	0.02
5	0.01
3	0.01
2	0.01
1	0.01

*The permissable tolerances on new weights shall be one-half the permissable tolerances on used weights.

4. Reference

AASHTO M 231

END OF TEXT

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 3
November, 1976
3 Pages

INDICATING WHICH PLACES OF FIGURES ARE TO BE CONSIDERED SIGNIFICANT IN SPECIFIED LIMITING VALUES

1. Scope

1.1 The purpose of this method is to outline a procedure for rounding numbers and rounding the results of arithmetic operations to the number of significant figures specified as limiting values in the specifications or standard testing procedures.

2. Significant Figures

2.1 Definition – The specified number of figures in any number expressed as an INTEGER and/or a decimal FRACTION, which, used with their place value, is an accepted APPROXIMATION for the number. The SIGNIFICANT FIGURES, or DIGITS, in the decimal form of a number are the digits reading from left to right, beginning with the first non-zero digit and ending with the last digit written.

NOTE – In the decimal notation, zeros are frequently used to fix the position of the decimal point, and such zeros do not have significance.

2.2 Examples –

NUMBER	FIGURES HAVING SIGNIFICANCE	NUMBER OF SIGNIFICANT FIGURES
0.0014	1,4	2
0.14000	1,4,0,0,0	5
2.03	2,0,3	3
52.20	5,2,2,0	4
12,900	1,2,9,0,0	5

3. Expression of Numerical Requirements

3.1 The unqualified statement of a numerical limit, such as "2.50 in. maximum", cannot, in view of different established practices and customs, be regarded as carrying a definite operational meaning concerning the number of places of figures to be retained in an observed or a calculated value for purposes of determining conformance with specifications.

3.2 Rounding-Off Method – In some fields, specified limiting values of 2.5 in. maximum, 2.50 in. maximum, 2.500 in. maximum are taken to imply that, for the purposes of determining conformance with specifications, an observed value or a calculated value should be rounded off to the nearest 0.1 in., 0.01 in., 0.001 in., respectively, and then compared with the specified limiting value. This will be referred to as the ROUNDING-OFF METHOD.

3.3 Absolute Method – In other fields, specified limiting values of 2.5 in. maximum, 2.50 in. maximum, and 2.500 in. maximum are all taken to imply the same absolute limit of exactly two and a half inches and for purposes of determining conformance with specifications, an observed value or a calculated value is to be compared directly with the specified value. Thus, any deviation, however small, outside the specified limiting value signifies non-conformance with the specifications. This will be referred to as the ABSOLUTE METHOD.

4. Rounding-Off Method

4.1 Where Applicable — The rounding-off method applies where it is the intent that a limited number of places of figures in an observed value or a calculated value are to be considered significant for purposes of determining conformance with specifications.

4.2 How Applied — With the rounding-off method, an observed value or a calculated value should be rounded off by the procedure prescribed in 3.2 to the nearest unit in the designated place of figures stated in the specifications or test standards, as, for example, "to the nearest 100 psi", "to the nearest 0.1 percent", etc. The rounded-off value should then be compared with the specified value, and conformance or non-conformance with the specification based on this comparison.

4.3 Rounding-Off Procedure — The actual rounding-off procedure shall be as follows:

4.3.1 Rounding Numbers

4.3.1.1 When the figure next beyond the last place to be retained is less than 5, the figure in the last place retained should be kept unchanged.

Example —— 28.44 is rounded to 28.4 if one decimal place (3 significant figures) is being kept.

4.3.1.2 When the figure next beyond the last figure or place to be retained is greater than 5, the figure in the last place retained should be increased by 1.

Example —— 28.46 is rounded to 28.5 if one decimal place (3 significant figures) is being kept.

4.3.1.3 When the figure next beyond the last figure to be retained is 5, and,

(a) there are no figures or are only zeros beyond this 5, an odd figure in the last place to be retained should be increased by 1, an even figure should be kept unchanged.
Example — 28.45 or 28.450 is rounded to 28.4 if one decimal place (3 significant figures) is being kept and 28.55 or 28.550 is rounded to 28.6 if one decimal place (3 significant figures) is being kept.

(b) If the 5 is followed by any figures other than zero, the figure in the last place to be retained should be increased by 1, whether odd or even.
Example — — 28.451 is rounded to 28.5 if one decimal place (3 significant figures) is being kept.

NOTE — A NUMBER SHOULD ALWAYS BE ROUNDED-OFF IN ONE STEP TO THE NUMBER OF FIGURES THAT ARE TO BE RECORDED, AND SHOULD NOT BE ROUNDED IN TWO OR MORE STEPS OF SUCCESSIVE ROUNDINGS.

4.3.2 Rounding the Results of Single Arithmetic Operations

4.3.2.1 Addition — When several approximate numbers are to added, the sum should be rounded to the number of decimal places (not significant figures) no greater than in the addend which has the smallest number of decimal places.

$$\text{Example —— }\begin{array}{l}4.01\\0.002\\\underline{0.623}\\4.635\end{array}$$

The sum should be rounded to and recorded as 4.64

NOTE — ALTHOUGH THE RESULT IS DETERMINED BY THE LEAST ACCURATE OF THE NUMBERS ENTERING THE OPERATION, ONE MORE DECIMAL PLACE IN THE "MORE ACCURATE" NUMBERS SHOULD BE RETAINED, THUS ELIMINATING INHERENT ERRORS IN THE NUMBERS.

4.3.2.2 Subtraction — When one approximate number is to be subtracted from another, they must both be rounded off to the same place before subtracting.

NOTE – ERRORS ARISING FROM THE SUBTRACTION OF NEARLY-EQUAL APPROXIMATE NUMBERS ARE FREQUENT AND TROUBLESOME, OFTEN MAKING THE COMPUTATION PRACTICALLY WORTHLESS. SUCH ERRORS CAN BE AVOIDED WHEN THE TWO NEARLY-EQUAL NUMBERS CAN BE APPROXIMATED TO MORE SIGNIFICANT DIGITS.

4.3.2.3 Multiplication – If the least accurate of two approximate numbers contains "N" significant digits, their product can be relied upon for "N" digits at most, and should not be written with more.

NOTE – AS A PRACTICAL WORKING PLAN, CARRY INTERMEDIATE COMPUTATIONS OUT IN FULL, AND ROUND OFF THE FINAL RESULT IN ACCORDANCE WITH THIS RULE.

4.3.2.4 Division –– if the least accurate number of either the divident or the divisor contains "N" significant digits, their quotient can be relied upon for "N" digits at most, and should not be written with more.

NOTE – CARRY INTERMEDIATE COMPUTATIONS OUT IN FULL, AND ROUND OFF THE FINAL RESULT IN ACCORDANCE WITH THIS RULE.

4.3.2.5 Power and Roots –– If an approximate number contains "N" significant digits, its power can be relied upon for "N" digits at most; its root can be relied upon for at least "N" digits.

4.3.3 Rounding The Results Of A Series Of Arithmetic Operations.

4.3.3.1 In computations involving more than one type of arithmetic operation round off the final reported number to the same number of significant figures as contained in the least-accurate number used in the computations.

5. Absolute Method

5.1 Where Applicable – The absolute method applies where it is the intent that all digits in an observed value or a calculated value are to be considered significant for purposes of determining conformance with specifications. Under these conditions, the specified limits are referred to as absolute limits.

5.2 How Applied – With the absolute method, an observed value or a calculated value is not to be rounded off, but is to be compared directly with the specified limiting value. Conformance or non-conformance with the specification is based on this comparison.

End of Text PTM 3
Reference ASTM E 29

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 4
November, 1976
3 Pages

Bureau of Materials, Testing and Research

Method of Test for
TREATMENT OF EXTREME VALUES

1. Scope

1.1 The purpose of this test method is to outline a procedure for dealing with extreme values when doing computations for control or acceptance testing.

1.2 Extreme values or OUTLIERS are those values from a collection of measurements that vary greatly from the average $\overline{X}$. This method indicates whether the outlier is beyond the normal distribution or not.

2. Procedure

2.1 Tabulate the measurement values, add them to obtain the sum and divide this sum by the number of measurements to obtain the average.

2.2 Obtain the difference between each measurement and this average, square each difference and add the results to obtain the sum of the squares of the differences.

2.3 Divide the sum of the squares of the differences by the number of measurements less one.

2.4 Find the square root of the value obtained in 2.3 above.

2.5 Divide the absolute difference between the average value obtained in 2.1 above and the suspected outlier value by the result obtained in 2.4 above.

2.6 Compare the result obtained in 2.5 above with the value shown in Table I for the number of observations (n) at the specified significance level. (The significance level will be given in the relevant specification).

2.7 If the value obtained in 2.5 above exceeds the Table I value, discard the suspected measurement and substitute another measurement obtained by appropriate means.

3. Example

Five bitumen content determinations were made by the extraction method on a lot of bituminous concrete. The material was an ID-2 wearing course mixture with a design specifying 6.0% bitumen. The results were as follows: (1) 6.0; (2) 5.8; (3) 5.7; (4) 6.1; and (5) 5.4.

We want to know if test #5 (5.4%) constitutes an outlier.

3.1 First obtain the average $\overline{X}$.

$$\overline{X} = \frac{\sum_{i=1}^{\eta} X_i}{n} = \frac{29.0}{5} = 5.8\%$$

3.2 Find the difference between each value and $\overline{X}$, square the difference and sum.

$$\text{Sum of square of differences} = \sum_{i=1}^{\eta} (X_i - \overline{X})^2 = 0.3$$

3.3 Divide the sum of squares of the differences by the number of measurements less one.

$$S^2 = \frac{\sum_{i=1}^{\eta} (X_i - \overline{X})^2}{n - 1} = \frac{0.3}{4} = 0.1$$

3.4 Find the standard deviation by taking the square root.

$$S = \sqrt{S^2} = \sqrt{0.1} = \underline{+}\ 0.3$$

3.5 Divide the difference between the average value (5.8) and the suspected outlier value (5.4) by the standard deviation. This is the T value:

$$T = \frac{\left| \overline{X} - X_{\text{suspected}} \right|}{S} = \quad T = \frac{5.8 - 5.4}{0.3} = 1.3$$

3.6 Compare the T value (1.3) with the value (1.67) shown in Table 1 for n = 5 and a significance level of 5%.

3.7 The value of T (1.3) does not exceed the T value (1.67) in Table I, therefore, the value of 5.4% bitumen is not considered an outlier.

End of Text PTM 4
Reference ASTM E 178

TABLE I

CRITICAL VALUES OF T (ONE-SIDED TEST) WHEN STANDARD DEVIATION IS CALCULATED FROM THE SAME SAMPLE

Number of Observations n	5 Percent Significance Level	2.5 Percent Significance Level	1 Percent Significance Level
3	1.15	1.15	1.15
4	1.46	1.48	1.49
5	1.67	1.71	1.75
6	1.82	1.89	1.94
7	1.94	2.02	2.10
8	2.03	2.13	2.22
9	2.11	2.21	2.52
10	2.18	2.29	2.41
11	2.23	2.36	2.48
12	2.29	2.41	2.55
13	2.33	2.46	2.61
14	2.37	2.51	2.66
15	2.41	2.55	2.71
16	2.44	2.59	2.75
17	2.47	2.62	2.79
18	2.50	2.65	2.82
19	2.53	2.68	2.85
20	2.56	2.71	2.88

Commonwealth of Pennsylvania
Department of Transportation

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2 Pages

Bureau of Materials, Testing and Research

Method of Test for

AMOUNT OF MATERIAL FINER THAN NO. 200 SIEVE IN AGGREGATE

1. Scope

1.1 This method of test, which is a modification of AASHTO T 11, outlines the procedure for determining the quantity of material finer than a standard No. 200 (0.075 mm) sieve in aggregate.

2. Apparatus and Reagent

2.1 Sieves – A nest of two sieves; the lower being a No. 200 sieve and the upper a No. 16 sieve, both conforming to PTM 117.

2.2 Container – A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without inadvertant loss of any part of the sample or water.

2.3 Balance – The balance shall conform to PTM 2 Class D for samples less than 2000 g; Class E for samples 2000 g or more, but less than 5000 g; or Class F for samples 5000 g or more. If a Class E balance is not available, the minimum mass of the test portion of 1-NS and #2 aggregate shall be not less than 5000 g and a Class F balance shall be used.

2.4 Oven – The oven shall be capable of maintaining a uniform temperature of 230 + 9 F (110 + 5 C) (NOTE 1).

NOTE 1 – Hot plates may be used when test results must be obtained quickly in the field. When test results are disputed, referee samples shall be tested using ovens as described above.

2.5 Dispersing Agent –

Chemical	Grams of chemical per liter of water
Sodium hexametaphosphate	45.7
Sodium tetraphosphate	35.1
Sodium tripolyphosphate	18.8
Sodium polyphos	21.6

Chemicals of technical grade are considered to be of sufficient parity. If none of the dispersing agents listed above are available, a household water softener or laundry detergent may be substituted except when testing referee samples for confirmation of disputed test results.

3. Test Samples

3.1 Obtain a sample in accordance with PTM 607. Select a test portion of the sample in accordance with PTM 625. The sample for test shall not be less than the appropriate mass of dried material as shown in the following table and shall be the end result of the selection method. Do not try to select a sample of an exact predetermined weight.

Material Size	Minimum Mass of Sample	
	kg	lb
Fine Aggregate	0.5	1.0
1B	1.0	2.0
1NS, #2	2.5	5.0
2B, 2A, 3A, 2NS	5.0	10.0

4. Procedure

4.1 Dry the test sample to constant weight at a temperature not exceeding 239 F, (115 C) weigh and record this and all succeeding weights to the nearest 0.2 percent (NOTE 2).

NOTE 2 – Never place hot material on a scale or balance. If the sample is too hot to handle, it is too hot to weigh accurately.

4.2 After drying and weighing, place the test sample in the container, add dispersing agent and water to cover, and stir. When the water, dispersing agent, and sample have been well mixed, allow it to sit for ten minutes. Then agitate the contents of the container vigorously and immediately pour the wash water over nested No. 200 and No. 16 sieves, arranged with the coarser sieve on top. The use of a large spoon to stir and agitate the aggregate in the wash water has been found satisfactory. (NOTE 3).

NOTE 3 — The use of rubber gloves is recommended. Water containing dispersing agent is a minor skin irritant.

4.3 The agitation should be sufficiently vigorous to result in the complete separation from the coarse particles of all particles finer than the No. 200 sieve and bring the fine material into suspension in order that it will be removed by decantation of the wash water. Take care to avoid, as much as possible, decantating the coarse particles of the sample. Without adding a dispersing agent repeat the operation until the wash water is clear.

4.4 Return all material retained on the nested sieves to the washed sample. Dry the washed aggregate to constant mass at a temperature not exceeding 239 F (115 C).

4.5 When the sample has been dried, remove it from the source of heat and permit it to cool to comfortable handling termperature (NOTE 2).

4.6 After cooling, weigh the sample and record the weight.

4.6.1 Fine Aggregate — Sieve the washed and dried sample as outlined in PTM 616 and then calculate the percent passing the No. 200 sieve in accordance with Sec. 5.2.

4.6.2 Long-Graded Aggregate and Coarse Aggregate — Calculate the percent passing the No. 200 sieve in accordance with Sec. 5.1.

5. Calculations

5.1 Long-Graded Aggregate and Coarse Aggregate — Calculate the percent finer than the No. 200 sieve according to the following formula:

$$P = \frac{O - W}{O} \times 100$$

Where:

O = Original dry weight of test sample as recorded in Sec. 4.1.

W = Weight of washed and dried sample as recorded in Sec. 4.6.

P = Percent of material finer than No. 200 sieve.

5.2 Fine Aggregate — Calculate the percent finer than the No. 200 sieve according to the following formula:

$$P = \frac{X + B}{O} \times 100$$

Where:

W = Weight of the washed and dried sample as recorded in Sec. 4.6.

P = Percent of material finer than the No. 200 sieve.

B = O — W

O = Original dry weight of test sample as recorded in Sec. 4.1.

X = Weight of material passing the No. 200 sieve determined in accordance with PTM 616.

6. Report

Report the percent passing the No. 200 sieve to the nearest whole number and record as material finer than No. 200 sieve.

7. References

PTM
PTM 117
PTM 607
PTM 616
PTM 625
AASHTO T 11

End of Text PTM 100

Commonwealth of Pennsylvania
Department of Transportation

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4 Pages

Bureau of Materials, Testing & Research

Method of Test for

THE MOISTURE-DENSITY RELATIONS OF SOILS
(Using a 5.5-Lb. Rammer and a 12-In. Drop)

1. Scope

1.1 This method of test, which is a modification of AASHO T 99 is intended for determining the relation between the moisture content and density of soils compacted in a mold of a given size with a 5.5 lb. rammer dropped from a height of 12 in. Method A is used when the test is run on the portion of the soil sample passing the 3/4 inch sieve, the material retained on the sieve being discarded. Method B is used when the test is run on a compensated sample of soil passing the 3/4 inch sieve, by replacing the amount retained on the sieve with an equal weight of material passing the 3/4 inch and retained on the No. 4 sieve, taken from the remaining portion of the sample.

2. Apparatus

2.1 Molds—The mold shall be cylindrical in shape, made of metal, and shall have the capacity and dimensions indicated in Section 2.1.1. It shall have a detachable collar assembly approximately 2½ in. in height, to permit preparation of compacted specimens of soil-water mixtures of the desired height and volume. The mold may be of the "split" type, consisting of two half-round sections, or a section of pipe split along one element, which can be securely locked in place to form a cylinder. The mold and collar assembly shall be so constructed that it can be fastened firmly to a detachable base place.

2.1.1 4.0-in. Mold having a capacity of 1/30 (0.0333) ± 0.0003 cu. ft., with an internal diameter of 4.00 ± 0.016 in. and a height of 4.584 ± 0.005 in. (See Figure 1)."

2.1.2 Molds shall be checked for adherence to tolerances annually. Molds may remain in use after continued service provided the original tolerances (see Section 2.1.1) are not exceeded by more than 50 percent. Molds meeting this stipulation shall be calibrated for volume according to Section 3 (Calibration of Measure) of PTM 609, for Unit Weight of Aggregates, and the found volume used in all subsequent calculations.

2.2 Rammer—A manually operated metal rammer of 2 in. diameter having a flat circular face and weighing 5.5 lb. The rammer shall be equipped with a suitable arrangement to control the height of drop to a free fall of 12 in. above the elevation of the soil.

2.3 Sample Extruder (optional) A jack, lever, frame or other device adapted for the purpose of extruding compacted specimens from the mold.

2.4 Balances—A balance or scale of at least 25 lb. capacity sensitive to 0.01 lb., and a balance of at least 1000 g capacity sensitive to 0.1 g.

2.5 Drying Equipment—Stove, oven, hot plate or other suitable equipment for drying moisture content samples or by a calcium carbine gas pressure meter in accordance with PTM 123.

2.6 Straight Edge—A steel straight—edge 12 in. in length and having one beveled edge.

2.7 Sieves—2 in., 3/4 in., and No. 4 (4760—micron) sieves conforming to the requirements of the Specifications for Sieves for Testing Purposes PTM 117.

2.8 Mixing Tools—Miscellaneous tools such as mixing pan, spoon, trowel, spatula, etc., or a suitable mechanical device for thoroughly mixing the sample of soil with increments of water.

3. Method A

3.1 Sample

3.1.1 If the soil sample is damp when received from the field, dry it until it becomes friable under a trowel. Drying may be in air of by use or drying apparatus such that the temperature of the sample does not exceed 140 F. Then thoroughly break up the aggregations in such a manner as to avoid reducing the natural size of the individual particles.

NOTE — When the material is granulated slag, the sample should be dried to approximately 4 percentage points below optimum moisture content.

3.1.2 Sieve an adequate quantity of the representative pulverized soil over the 3/4 in. sieve. Discard the coarse material, if any, retained on the 3/4 in. sieve.

3.1.3 Select a representative sample, weighing approximately 12 lb., or more, of the soil prepared as described in Sections 3.1.1 and 3.1.2.

4. Method B

4.1 Sample

4.1.1 If the soil sample is damp when received from the field, dry it until it becomes friable under a trowel. Drying may be in air or by use of drying apparatus such that the temperature of the sample does not exceed 140 F. Then thoroughly break up the aggregations in such a manner as to avoid reducing the natural size of individual particles.

NOTE — When the material is granulated slag, the sample should be dried to approximately 4 percentage points below optimum moisture content.

4.1.2 Sieve an adequate quantity of the representative pulverized soil over a 3/4 in. sieve. Discard any large oversize pieces. Weigh the material retained on the 3/4 in. sieve and replace it with an equal weight of material passing the 3/4 in. sieve and retained on the No. 4 sieve. Take the material for replacement from the remaining portion of the sample.

4.1.3 Select a representative sample, weighing approximately 12 lb. or more of the soil prepared as described in Sections 4.1.1 and 4.1.2.

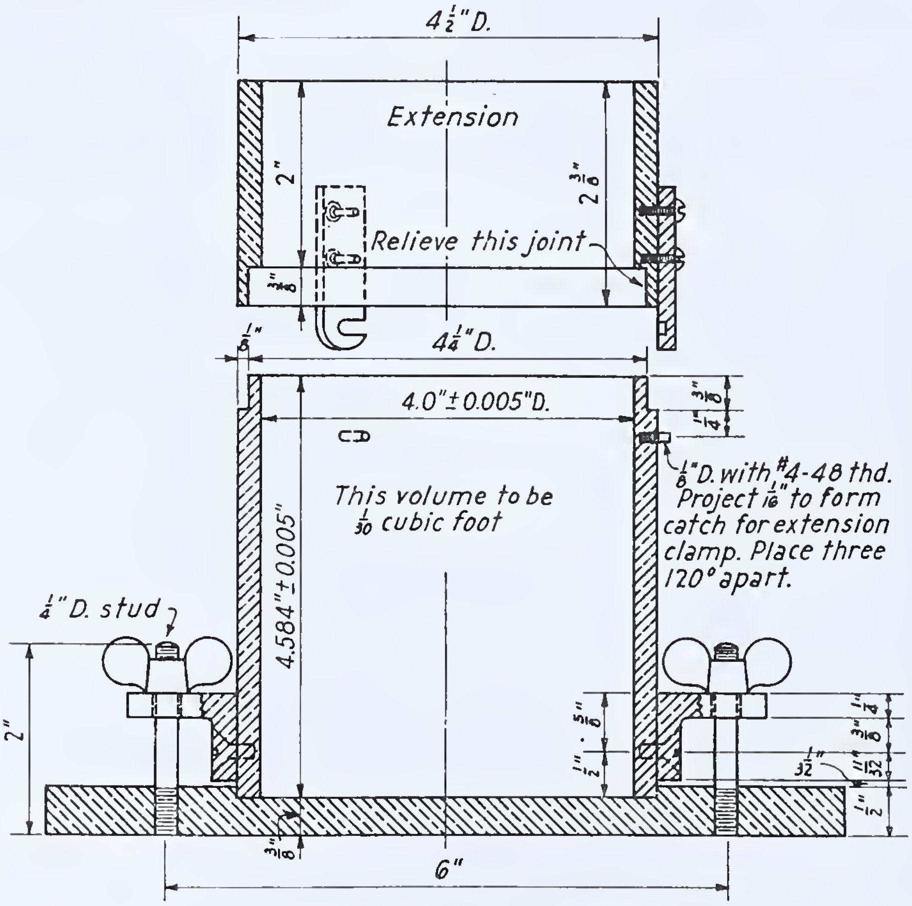


FIG. 1.—Cylindrical Mold, 4.0-in., for Soil Tests.

5. Procedure

5.1 Thoroughly mix the selected representative sample with sufficient water to dampen it to approximately 4 percentage points below optimum moisture content.

5.2 Form a specimen by compacting the prepared soil in the 4-in. mold (with collar attached) in three equal layers to give a total compacted depth of about 5 in. Compact each layer by 25 uniformly distributed blows from the rammer, dropping free from a height of 12 in. above the elevation of the soil when a sleeve–type rammer is used, or from 12 in. above the approximate elevation of each finally compacted layer when a stationary mounted type of rammer is used. During compaction, the mold shall rest on a uniform, rigid foundation, such as is provided by a cube of concrete weighing not less than 200 lb. Following compaction, remove the extension collar, and carefully trim the compacted soil even with the top of the mold by means of the straightedge. Holes developed in the surface by removal of coarse material shall be patched with smaller size material. Weigh the mold and moist soil. Multiply the weight of the compacted specimen and mold, minus the weight of the mold, by 30, and record the result as the wet weight per cubic foot of the compacted soil.

5.3 Remove the material from the mold and slice vertically through the center. Take a representative sample of the material from one of the cut faces, weight immediately, and dry in an oven at 110±5 C. (230±9 F.) for at least 12 hr., or to constant weight, on a hot plate or in accordance with PTM 123 to determine the moisture content. The moisture content sample shall weigh not less than 200 g.

5.4 Thoroughly break up the remainder of the material until it will pass a 3/4 inch sieve and 90 percent of soil aggregations will pass a No. 4 sieve as judged by eye, and add to the remaining portion of the sample being tested. Add water in sufficient amounts to increase the moisture content of the soil sample by one or two percentage points, and repeat the above procedure for each increment of water added. Continue this series of determinations until there is either a decrease or no change in the wet weight per cubic foot of the compacted soil.

NOTE–Another procedure is by the use of separate samples. In instances where the soil material is fragile in character and will reduce significantly in grain size due to repeated compaction, and in cases where the soil is heavy–textured clayey material into which it is difficult to incorporate water, a separate and new sample shall be used in each compaction test. In these cases, separate samples shall be thoroughly mixed with amounts of water sufficient to cause the moisture contents of the samples to vary by approximately two percentage points. The moisture contents selected shall bracket the optimum moisture content, thus providing samples which, when compacted, will increase in weight to the maximum density and then decrease in weight.

6. Calculations and Report

6.1 Calculations

6.1.1 Calculate the moisture content and the dry weight of the soil as compacted for each trial, as follows:

$$W = \frac{W_1 - W_2 \times 100}{W_2 - P}$$

and

$$D = \frac{D_w \times 100}{M + 100}$$

where:
M = percentage of moisture in the specimen, based on dry weight
W_1 = moist weight of sample including pan, in grams
W_2 = dry weight of sample including pan, in grams
P = weight of pan in grams
D_w = wet density of compacted soil specimen, in pounds per cubic foot
D = dry density of compacted soil specimen, in pounds per cubic foot

7. Moisture–Density Relationship

7.1 The calculations in Section 6.1.1 shall be made to determine the moisture content and corresponding oven–dry weight (density) for each of the compacted soil samples. The oven–dry weights per cubic foot (densities) of the soil shall be plotted as ordinates and corresponding moisture contents as abscissas.

7.2 Optimum Moisture Content.—When the densities and corresponding moisture contents for the soil have been determined and plotted as indicated in Section 7.1, it will be found that by connecting the plotted points with a smooth line, a curve is produced. The moisture content corresponding to the peak of the curve shall be termed the "optimum moisture content" of the soil under the above compaction. The smooth curve should be a free-hand approximation of a parabola. The use of a straight-edge in drawing the curve is discouraged. A zero air voids line may be added to the graph only when it is appropriate to the measured specific gravity of the sample.

7.3 Maximum Density.—The oven-dry weight per cubic foot of the soil at optimum moisture content shall be termed "maximum density" under the above compaction.

8. Report

8.1 The report shall include the following:

8.1.1 The optimum moisture content,
8.1.2 The maximum density, and
8.1.3 Indicate if Method A or Method B was used.

9. References

AASHO T 99
ASTM D 698
PDT Bulletin 39

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 108
July, 1968
2 Pages

Bureau of Materials Testing & Research

METHOD OF TEST FOR

CLAY LUMPS IN NATURAL AGGREGATES

1. SCOPE

1.1 This method of test, which is in accordance with ASSHO T 112 covers the procedure for the approximate determination of clay lumps in natural aggregates.

2. APPARATUS

2.1 The apparatus shall consist of the following:

2.1.1 Balance.—Balance or scale sensitive to within 0.1 per cent of the weight of the sample to be weighed.

2.1.2 Containers.—Containers of a size and shape that will permit the spreading of the sample on the bottom in a thin layer.

2.1.3 Sieves.—Sieves conforming to the Specifications for Sieves for Testing Purposes PTM 117.

3. SAMPLES

3.1 Samples for this test shall consist of the material remaining after completion of the Test for Materials Finer than No. 100 or No. 200 Sieve in Mineral Aggregates by Washing PTM 100. To provide the quantities designated in Sections 3.3 and 3.4, it may be necessary to combine material from more than one test by PTM 100.

3.2 Samples shall be dried to substantially constant weight at a temperature not exceeding 110 C. (230 F.).

3.3 Samples of fine aggregate shall consist of the particles coarser than a No. 16 (1190-micron) sieve and shall weigh not less than 100 g.

3.4 Samples of coarse aggregate shall be separated into different sizes using the following sieves: No. 4 (4760-micron), 3/8-in., 3/4-in., and 1 1/2-in. The weight of sample for the different sizes shall be not less than indicated in the following table:

Size of Particles making up sample	Weight of sample, min., g.
No. 4 to 3/8-in.	1000
3/8 to 3/4-in.	2000
3/4 to 1 1/2-in.	3000
Over 1 1/2-in.	5000

3.5 In the case of mixtures of fine and coarse aggregates, the material shall be separated into two sizes on the No. 4 (4760-micron) sieve, and the samples of fine and coarse aggregates shall be prepared in accordance with sections 3.3 and 3.4.

4. PROCEDURE

4.1 The sample shall be spread in a thin layer on the bottom of the container and examined for clay lumps. Any particles which can be broken into finely divided particles with the fingers shall be classified as clay lumps. After all discernible clay lumps have been broken, the residue from the clay lumps shall be removed by use of the sieves indicated in the following table:

Size of particles making up sample	Size of sieve for sieving residue of clay lumps
Fine aggregate (retained on No. 16 (1190-micron) sieve)	No. 20 (840-micron)
No. 4 to 3/8-in.	No. 8 (2380-micron)
3/8 to 3/4-in.	No. 4 (4760-micron)
3/4 to 1 1/2-in.	No. 4 (4760-micron)
Over 1 1/2-in.	No. 4 (4760-micron)

5. CALCULATION

5.1 The percentage of clay lumps shall be calculated to the nearest 0.1 per cent in accordance with the following formula:

$$L = \frac{W - R}{W} X\ 100$$

where:
L = percentage of clay lumps,
W = weight of sample, and
R = weight of sample after removal of clay lumps.

End of Text PTM 108
Reference AASHO T 112

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 109
July, 1968
4 Pages

Bureau of Materials Testing & Research

Methods of Test for

MOISTURE-DENSITY RELATIONS OF SOIL-CEMENT MIXTURES

1. Scope

1.1 These methods of test, which are in accordance with AASHO T134 cover precedures for determining the relationship between the moisture content and the density of soil-cement mixtures when compacted before cement hydration as prescribed.

1.2 A 1/30-cu ft mold and 5.5-lb rammer dropped from a height of 12 in. are used and two methods, depending on soil gradation, are covered, as follows:

	Sections
Method A, using soil material passing a No. 4 (4760-micron) sieve. This method shall be used when 100 per cent of the soil sample passes the No. 4 (4760-micron) sieve	3
Method B, using soil material passing a ¾-in. sieve. This method shall be used when part of the soil sample is retained on the No. 4 (4760-micron) sieve	4

2. Apparatus

2.1 Mold.—A cylindrical metal mold having a capacity of 1/30 cu ft with an internal diameter of 4.0 ± 0.005 in. and a height of 4.584 ± 0.005 in., to permit preparing compacted specimens of soil-cement mixtures of this size. The mold shall be provided with a detachable collar assembly approximately 2½ in. in height. The mold may be of the split type consisting of two half-round sections or a section of pipe with one side split perpendicular to the pipe circumference and that can be securely locked in place to form a closed cylinder having the dimensions described above. The mold and collar assembly shall be so constructed that it can be fastened firmly to a detachable base (Fig. 1 PTM 106).

2.2 Rammer.—A metal rammer having a 2-in. diameter circular face and weighing 5.5 lb. The rammer shall be equipped with a suitable arrangement to control the height of drop to a free fall of 12 in. above the elevation of the soil-cement.

2.3 Sample Extruder.—A jack, lever frame, or other device adapted for the purpose of extruding compacted specimens from the mold. Not required when a split-type mold is used.

2.4 Balances.—A balance or scale of at least 25-lb capacity sensitive to 0.01 lb; and a balance of at least 1000-g capacity sensitive to 0.1 g.

2.5 Drying Oven.—A thermostatically controlled drying oven capable of maintaining a temperature of 230 ± 9F (110 ± 5 C) for drying moisture samples.

2.6 Straightedge.—A rigid steel straight-edge 12 in. in length and having one beveled edge.

2.7 Sieves.—2½-in. ¾-in., and No. 4 (4760-micron) sieves conforming to the requirements of the Specifications for Sieves for Testing Purposes PTM 117.

2.8 Mixing Tools.—Miscellaneous tools such as mixing pan, spoon, trowel, and spatula, or a suitable mechanical device for thoroughly mixing the sample of soil with cement and with increments of water.

2.9 Container.—A flat, round pan for moisture absorption by soil-cement mixtures, about 12 in. in diameter and 2 in. deep.

2.10 Moisture Cans.—Suitable containers for moisture samples.

2.11 Butcher Knife.—A butcher knife approximately 10 in. in length for spading around the material in the mold to insure good distribution of soil particles before compaction.

3. Method A. Using Soil Material Passing a No. 4 (4760-Micron) Sieve

3.1 Sample

3.1.1 Prepare the sample for testing by breaking up the soil aggregations to pass the No. 4 (4760-micron) sieve in such a manner as to avoid reducing the natural size of the individual particles. When necessary, first dry the sample until it is friable under a trowel. Drying may be accomplished by air drying or by the use of drying apparatus such that the temperature of the sample does not exceed 140 F (60 C).

3.1.2 Select a representative sample, weighing approximately 6 lb or more, of the soil prepared as described in Section 3.1.1.

3.2 Procedure

3.2.1 Add to the soil the required amount of cement conforming to the Specifications for Type NB or NC, Section 701.2, Form 408. Mix the cement and soil thoroughly to a uniform color. When needed, add sufficient potable water to dampen the mixture to approximately four to six percentage points below the estimated optimum moisture content and mix thoroughly. At this moisture content, plastic soils, tightly squeezed in the palm of the hand, will form a cast that will fracture with only slight pressure applied by the thumb and fingertips; nonplastic soils will bulk noticeably. When the soil is a heavy-textured clayey material, compact the mixture of soil, cement, and water in the container to a depth of about 2 in. using the rammer described in Section 2.2 or a similar hand tamper. Cover, and allow to stand for not less than 5 min but not more than 10 min to aid dispersion of the moisture and to permit more complete absorption by the soil-cement. After the absorption period, thoroughly break up the mixture, without reducing the natural size of individual particles, until it will pass a No. 4 sieve and then remix.

3.2.2 Form specimen by compacting the prepared soil-cement mixture in the mold, with the collar attached, in three equal layers so as to give a total compacted depth of about 5 in. Compact each layer by 25 blows from the rammer dropping free from a height of 12 in. above the elevation of the soil-cement when a sleeve-type rammer is used, or from 12 in. above the approximate elevation of each finally compacted layer when a stationary-mounted type rammer is used. The blows shall be uniformly distributed over the surface of the layer being compacted. During compaction, the mold shall rest on a uniform, rigid foundation such as provided by a cube of concrete weighing not less than 200 lb. Following compaction, remove the extension collar, carefully trim the compacted mixture even with the top of the mold by means of the knife and straight-edge, and weigh. Multiply the weight of the compacted specimen and mold, minus the weight of the mold, by 30; record the result as the wet weight per cubic foot, W_1 of the compacted soil-cement mixture.

3.2.3. Remove the material from the mold and slice vertically through the center. Take a representative sample of the material, weighing not less than 100 g, from the full height of one of the cut faces, weigh immediately, and dry in an oven at 230 ± 9 F (110 ± 5C) for at least 12 hr or to constant weight. Calculate the moisture content of the sample as directed in Section 5.1. Record the result as the moisture content, w, of the compacted soil-cement mixture.

3.2.4 Thoroughly break up the remaining portion of the molded specimen until it will pass a No. 4 sieve as judged by eye, and add to the remaining portion of the sample being tested. Add water in sufficient amount to increase the moisture content of the soil-cement mixture by one or two percentage points, mix, and repeat the procedure given in Sections 3.2.2 and 3.2.3 for each increment of water added. Continue this series of determinations until there is either a decrease or no change in the wet weight per cubic foot, W_1 of the compacted soil-cement mixture.

4. Method B. Using Material Passing a ¾-in. Sieve

4.1 Sample

4.1.1 Prepare the sample for testing by segregating the aggregate retained on a No. 4 (4760-micron) sieve and breaking up the remaining soil aggregations to pass the No. 4 sieve in such a manner as to avoid reducing the natural size of individual particles. When necessary, first dry the sample until it is friable under a trowel. Drying may be accomplished by air drying or by the use of drying apparatus such that the temperature of the sample does not exceed 140 F (60C).

4.1.2 Sieve the prepared soil over the 2½-in., ¾-in., and No. 4 sieves. Discard the material retained on the 2½-in. sieve. Determine the percentage of material, by oven-dry weight, retained on the ¾-in. and No. 4 sieves. Saturate the aggregate passing the ¾-in. sieve and retained on the No. 4 sieve by soaking in potable water; surface-dry the material as required for later testing.

4.1.3 Select and maintain separate representative samples of soil passing the No. 4 sieve and of saturated, surface-dry aggregate passing the ¾-in. sieve and retained on the No. 4 sieve so that the total sample will weigh approximately 11 lb or more. The percentage, by oven-dry weight, of aggregate passing the ¾-in. sieve and retained on the No. 4 sieve shall be the same as the percentage passing the 2½-in. sieve and retained on the No. 4 sieve in the original sample.

4.2 Procedure

4.2.1 Add to the portion of the soil sample passing the No. 4 sieve, the amount of cement required for the total sample specified in Section 4.1.3. Mix the cement and soil thoroughly to a uniform color. When needed, add water to this soil-cement mixture and facilitate moisture dispersion as described for Method A in Section 3.2.1. After this preparation, add the saturated, surface-dry aggregate to the soil-cement mixture passing the No. 4 sieve and mix thoroughly.

4.2.2 Form a specimen by compacting the prepared soil-cement mixture in the mold (with the collar attached) and trim and weigh the compacted specimen as described for Method A in Section 3.2.2. During the trimming operation remove all particles that extend above the top level of the mold. Correct all irregularities in the surface by hand-tamping fine material into these irregularities and leveling the specimen again with the straightedge. Multiply the weight of the compacted specimen and mold, minus the weight of the mold, by 30; record the result as the wet weight per cubic foot, W_1, of the compacted soil-cement mixture.

4.2.3 Remove the material from the mold and take a sample for determining the moisture content as described for Method A in Section 3.2.3, except that the moisture sample shall weigh not less than 500 g. Record the result as the moisture content, w, of the compacted soil-cement mixture.

4.2.4. Thoroughly break up the remainder of the material as before until it will pass a ¾-in. sieve and at least 90 per cent of the soil particles smaller than a No. 4 sieve will pass a No. 4 sieve, as judged by eye, and add all other material remaining after obtaining the moisture sample. Add sufficient water to increase the moisture content of the soil-cement mixture by one or two percentage points, mix, and repeat the procedure described in Sections 4.2.2 and 4.2.3 for each increment of water added. Continue this series of determinations until there is either a decrease or no change in the wet weight per cubic foot, W_1, of the compacted soil-cement mixture.

5. Calculations

5.1 Calculate the moisture content and over-dry weight per cubic foot of the compacted soil-cement mixture for each trial as follows:

$$w = \frac{A - B}{B - C} X 100$$

$$W = \frac{W_1}{w + 100} X 100$$

where:
W = percentage of moisture in the specimen,
A = weight of moisture can and wet soil-cement,
B = weight of moisture can and oven-dry soil-cement,
C =weight of moisture can,
W = oven-dry weight in pounds per cubic foot of compacted soil-cement, and
W_1 = wet weight in pounds per cubic foot of compacted soil-cement.

5.2 Moisture-Density Relationship

5.2.1 The calculations in Section 5.1 shall be made to determine the moisture content and corresponding oven-dry weight per cubic foot (density) for each of the compacted soil-cement samples. The oven-dry weights per cubic foot (densities) of the soil-cement mixture shall be plotted as ordinates and the corresponding moisture contents as abscissas.

5.2.2 Optimum Moisture Content.—When the densities and corresponding moisture contents for the soil-cement mixture have been determined and plotted as indicated in Section 5.2.1 it will be found that by connecting the plotted points with a smooth line, a curve is produced. The moisture content corresponding to the peak of the curve shall be termed the "optimum moisture content" of the soil-cement mixture under the compaction prescribed in these methods.

5.2.3 Maximum Density.—The oven-dry weight per cubic foot of the soil-cement mixture at "optimum moisture content" shall be termed "maximum density" under the compaction prescribed in these methods.

6. Reports

6.1 The report shall include the following:

6.1.1 The optimum moisture content,
6.1.2 The maximum density.

7. Reference:

AASHO T 134

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 112
January 1969
5 Pages

Bureau of Materials, Testing and Research

Method of Test for

DENSITY OF SOIL IN–PLACE
(By the Sand–Cone Method)

1. Scope

1.1 This method of test, which is a modification of AASHO T 191 is intended for determining the in-place density of soils. The apparatus described herein is restricted to tests in soils containing particles not larger than 2 in. in diamater.

2. Apparatus

2.1 Density Apparatus.—The density apparatus shall consist of a 1 gal. jar and a detachable appliance consisting of a cylindrical valve with an orifice ½ in. in diameter and having a small funnel continuing to a standard G mason jar top on one end and a large funnel on the other end. The valve shall have stops to prevent rotating the valve past the completely open or completely closed positions. The apparatus shall conform to the requirements shown in Fig. 1 (Note 1).

NOTE 1. The apparatus described here represents a design that has proven satisfactory. Other apparatus of similar proportions will perform equally well so long as the basic principles of the sand–volume determination are observed. This apparatus, when full, can be used with test holes having a volume of approximately 0.1 cu. ft. The base plate shown in the drawing is optional. A metal template may be used as a guide to dig the hole and reduce the loss in transferring soil to the container.

2.2 Sand — The sand used in this test shall meet the requirements of Appendix I.

2.3 Balances — A balance or scale of at least 25 lb. capacity accurate to 0.01 lb. and a balance of 1000 gram capacity accurate to 0.1 gram.

2.4 Drying Equipment - Stove, oven hot plate or other suitable equipment for drying moisture content samples, or by a calcium carbide gas pressure meter in accordance with PTM 123.

2.5 Miscellaneous Equipment — Small pick, chisels, spoons for digging test hole; suitable container for drying moisture samples; buckets, gallon cans with lids, seamless tin cans with lids, sample bags or other suitable containers for retaining the density sample, moisture sample or density sand respectively; brushes, notebook, charts, etc.

3. Procedure

3.1 Determine the density of the soil in place as follows:

3.1.1 Fill the apparatus with sand to a specific weight. close the valve, and record the weight.

3.1.2 Prepare the surface of the location to be tested so that it is a level plane.

3.1.3 Seat the metal template on the prepared surface.

3.1.4 Dig the test hole inside the template guide being very careful to avoid disturbing the soil that will bound the hole. Soils that are essentially granular require extreme care. Place all loosened soil in a container being careful to avoid losing any material.

3.1.5 Remove the template and center the apparatus over the test hole. Open the valve and after the sand has stopped flowing, close the valve.

3.1.6 Weigh the apparatus with the remaining sand and determine the weight of sand used in the test.

3.1.7 Weigh the material that was removed from the test hole.

3.1.8 Mix the material thoroughly and secure and weigh a representative sample for moisture determination.

3.1.9 Dry and weigh the moisture sample.

3.2 The test hole volume shall be as large as practicable in determining the in place density of soil. The minimum test hole volume of soil shall be 0.050 cubic feet. The minimum weight of the moisture sample shall be 200 grams.

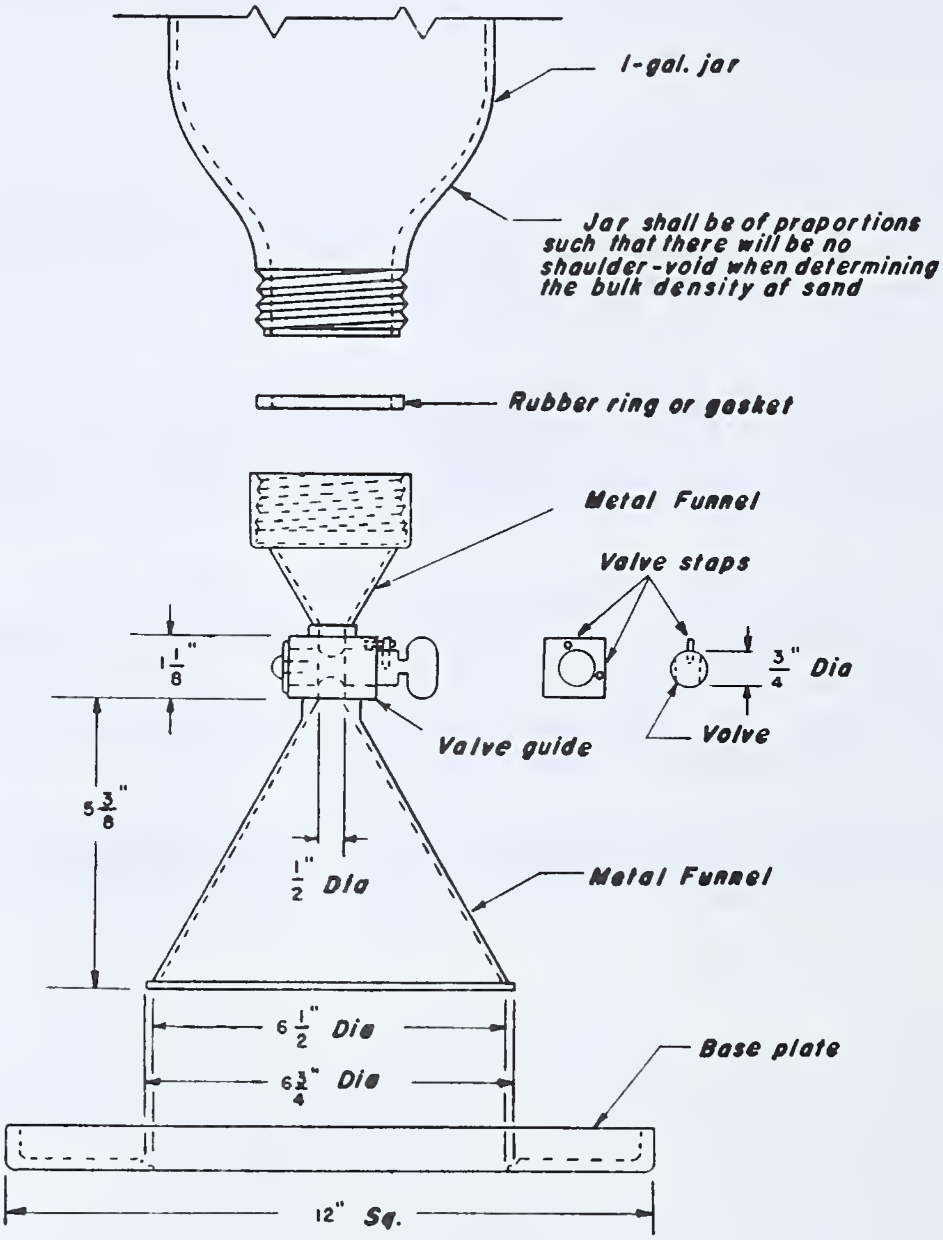


FIG. 1.—Density Apparatus.

4. Calculations

4.1 Calculate the moisture content of the material removed from the test hole in accordance with P.T.M. 123 or as follows:

$$M = \frac{W_1 - W_2 \times 100}{W_2 - P}$$

where:
M = Percentage of moisture in material from test hole
W_1= moist weight of sample including pan, in grams
W_2= dry weight of sample including pan, in grams
P = weight of pan in grams

4.2 Calculate the volume of the test hole as follows:

$$V= \frac{W_3 - W_4}{D_s}$$

where:
V = volume of test hole in cubic feet
W_3= weight of sand used in pounds (Section 3.1.6)
W_4= weight of sand in funnel (upper cone) in pounds (in accordance with Appendix 1)
D_s= bulk density of sand used in test in pounds per cubic foot (in accordance with Appendix 1)

4.3 Calculate the wet density of the material tested as follows:

$$D_w = \frac{W_w}{V}$$

where:
D_w= wet density of material in pounds per cubic foot
W_w= weight of material from test hole in pounds (Section 3.1.7)
V = volume of test hole in cubic feet (Section 4.2)

4.4 Calculate the dry density of material from test hole as follows:

$$D= \frac{D_w \times 100}{M + 100}$$

where:
D = dry density of material in pounds per cubic foot
D_w= wet density of material in pounds per cubic foot (Section 4.3)
M = percentage of moisture in material (Section 4.1)

4.5 Calculate the percent compaction of the in place density as follows:

$$C= \frac{D \times 100}{D_m}$$

where:
C = percent compaction of the in place density
D = dry density of material from test hole in pounds per cubic foot (Section 4.4)
D_m= maximum dry density of material in pounds per cubic foot (in accordance with PTM 106)

5. Report

5.1 The report shall be recorded on P.D.H. Form 478.

6. References

AASHO T 191
ASTM D 1556
PDH Bulletin 39

Appendix I

CALIBRATION OF SAND AND EQUIPMENT

PTM No. 112 January 1969

1. Scope

1.1 This method of test which is a modification of A.A.S.H.O. T191 is intended for determining the bulk density of sand used in the Sand Cone Method.

2. Apparatus

2.1 Sand Cone Density Apparatus – The density apparatus shall consist of a 1 gallon jar and detachable appliance consisting of a cylindrical valve with an orifice ½ inch in diameter and having a small funnel continuing to a standard G Mason jar top on one end and a large funnel (upper cone) on the other. The valve shall have stops to prevent rotating the valve past the completely open or completely closed positions.

The apparatus shall conform to the requirements shown in Figure 1.

2.2 Sand – Any clean, dry, free flowing uncemented sand with rounded particles having few, if any, particles passing the No. 200 or retained on the No. 10 sieves. The sand shall be packaged in moisture–proof bags.

2.3 Balances – A balance or scale of at least 25 lb. capacity accurate to 0.01 lb., and a balance of 1000 gram capacity accurate to 0.1 gram.

2.4 Miscellaneous Equipment – Sampling bags, buckets, tin cans, brushes, scoop, rubber gaskets, notebook, etc.

3. Procedure

3.1 Determine the volume of the jar and attachment up to and including the volume of valve orifice as follows.

3.1.1 Weigh the assembled apparatus and record
3.1.2 Place the apparatus upright and open the valve
3.1.3 Fill the apparatus with water until it appears over the valve
3.1.4 Close the valve and remove excess water
3.1.5 Weigh the apparatus and water and determine the net weight of water by subtracting weight of apparatus.
3.1.6 Repeat the procedure described in Section 3.1.1 to 3.1.5 at least twice.

NOTE 1: The volume determined in this procedure is constant as long as the jar and attachment are in the same relative position. If the two are to be separated match marks should be made to permit reassembly to this position.

Convert the weight of water in pounds into cubic feet. The volume used shall be the average of three determinations with a maximum variation of 0.005 cubic feet.

3.2 Determine the bulk density of the sand to be used in the field test as follows:

NOTE 2: Vibration of the sand during any sand weight–volume determination may increase the bulk density of the sand and decrease the accuracy of the determination. Appreciable time intervals between the bulk density determination of sand and its use in the field may result in change in the bulk density caused by a change in the moisture content or effective gradation.

3.2.1 Place the empty apparatus upright on a firm level surface, close the valve and fill the funnel (upper cone) with sand.

3.2.2 Open valve and, keeping funnel (upper cone) at least half full of sand, fill the apparatus. Close valve sharply and empty excess sand.

3.2.3 Weigh apparatus with sand and determine the net weight of sand by subtracting the weight of the apparatus.

3.2.4 Repeat the procedure described in Sections 3.2.1 to 3.2.3 at least twice using a new sample of sand each time.

The weight of sand used in pounds shall be the average of three determinations with a maximum variation of 1 percent.

3.3 Determine the weight of sand required to fill the funnel (upper cone) as follows.

3.3.1 Put a sufficient amount of sand in the apparatus and secure the weight of apparatus and sand.

3.3.2 Seat the inverted apparatus on a clean, level, plane surface.

3.3.3 Open the valve and keep open until after the sand stops running.

3.3.4 Close the valve sharply, weigh the apparatus with the remaining sand and determine the loss of sand, this loss represents the weight of sand required to fill the funnel (upper cone).

3.3.5 Repeat the procedure described in Section 3.3.1 to 3.3.4 at least twice.

NOTE 3: **When a base plate or metal template is used to determine the density of the soil in place it shall be considered a part of the funnel (upper cone).**

The weight of sand used in pounds shall be the average of three determinations with a maximum variation of 0.05 of a pound.

NOTE 4: **It is possible to determine the bulk density of the sand in other containers that approximate the largest test hole that will be dug. The general procedure in determining the volume, and the sand density by use of the sand cone apparatus,is as described herein.**

NOTE 5: **The determination of bulk density of the sand shall be made periodically and for each new source of sand.**

4. Calculations

4.1 Calculate the volume of the density apparatus as follows:

$$V = \frac{W}{62.427}$$

where:
V = volume of the density apparatus in cubic feet
W = weight of water in the density apparatus in pounds

4.2 Calculate the bulk density of the sand as follows:

$$D_s = \frac{W_s}{V}$$

where:
D_s = bulk density of the sand in pounds per cubic foot
W_s = weight of sand in the density apparatus in pounds
V = volume of the density apparatus in cubic feet

5. Report

5.1 The results shall be recorded on a specified form and include the following:

5.1.1 The determinations to obtain the average volume of the apparatus.
5.1.2 The determinations to obtain the average weight of sand in the apparatus.
5.1.3 The determinations to obtain the average weight of sand in the funnel (upper cone).
5.1.4 The average bulk density of the sand.
5.1.5 The identification of the sand source.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 113
March 1974
6 Pages

Bureau of Materials, Testing & Research

Method of Test for

THE CALIFORNIA BEARING RATIO

1. Scope

1.1 This method of test is intended for determining the bearing value of soils-aggregates when they are compacted in the laboratory at optimum moisture content to varying degrees of density using a 5.5-lb. hammer dropped from a height of 12-inches. The test is useful for evaluating subgrade soils and some subbase and base course materials containing only a small amount of material retained on the 3/4-inch sieve.

2. Apparatus

2.1 Molds.—The molds shall be cylindrical in shape, made of metal, with an internal diameter of 6.0 ± 0.026-in. and a height of 7.0 ± 0.026-in., provided with an extension collar approximately 2.0-in. in height and a perforated base plate that can be fitted to either end of the mold (See Fig. 1). It is desirable to have at least 3 molds for each soil to be tested.

2.2 Spacer Disk.—A circular spacer disk, made of metal 5-15/16 ± 1/32-in. in diameter and 2.416 ± 0.005-in. in height (See Fig. 1).

NOTE 1. When using molds having a height of 7.0-in. (See Fig. 1), a spacer disk height of 2.416-in. is needed to obtain a thickness of compacted specimen that conforms to the thickness (4.584-in.) of specimens in PTM 106 and AASHO 180.

2.3 Rammer.—A rammer weighing 5.5-lb. and having a 2-in. diameter circular striking face. It is equipped to control the height of drop to a free fall of 12-in. above the elevation of the soil. This is the metal rammer specified in PTM 106.

2.4 Apparatus for Measuring Expansion.—This consists of a swell plate with adjustable stem (Fig. 1) and a tripod support for a dial indicator (Fig. 1). The swell plate is made of metal, 5-7/8-in. in diameter and is perforated with 1/16-in. diameter holes. The tripod used to support the dial indicator is arranged to fit the mold extension collar.

2.5 Dial Indicators.—Two dial indicators; each indicator shall have a 1-in. throw and read to 0.001-in.

2.6 Surcharge Weights.—One annular metal weight with a center hole 2-1/8-in. in diameter, and several slotted or split metal weights, all 5-7/8-in. in diameter and each weighing 5 ± 0.10-lb. (Fig. 1).

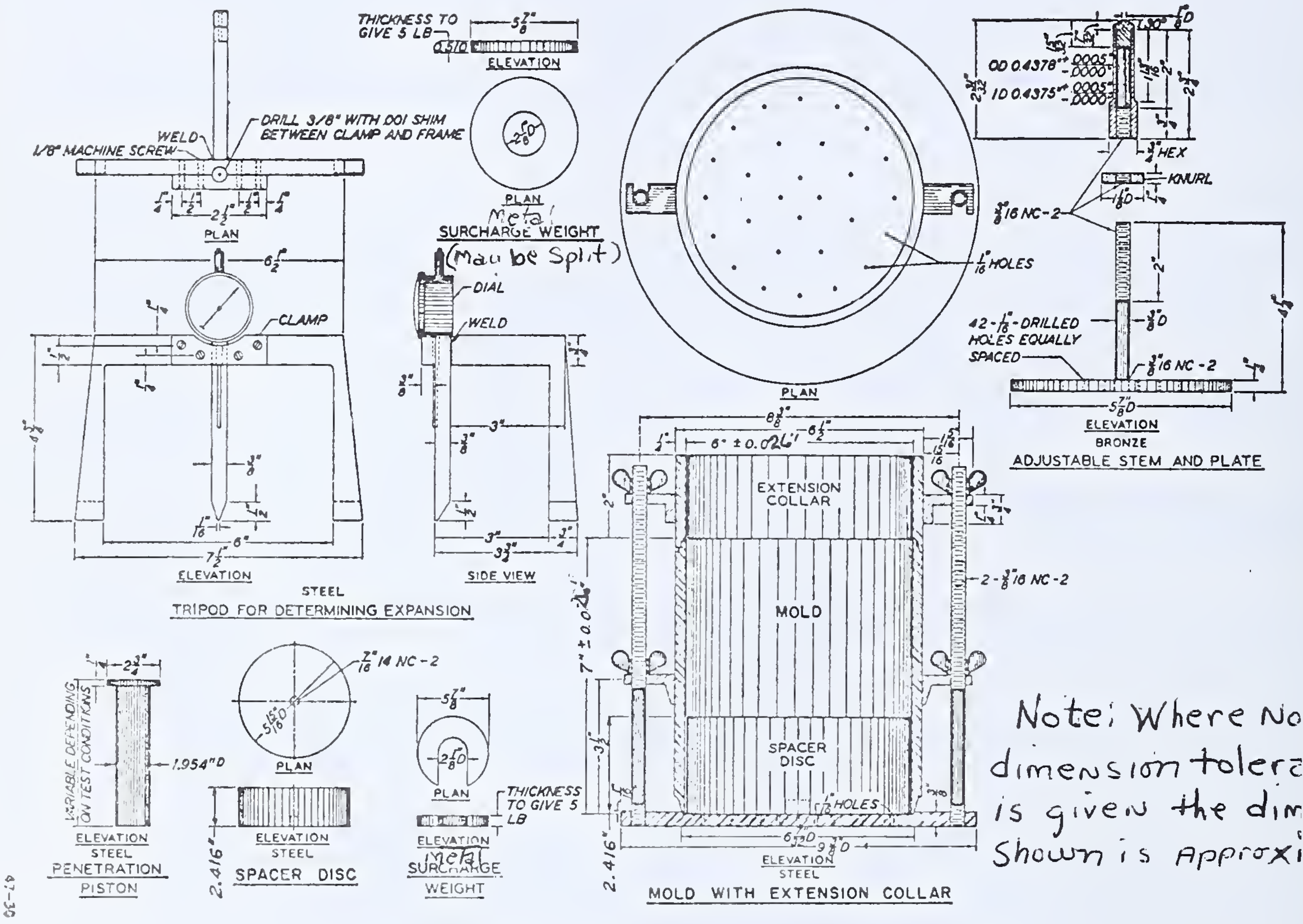
2.7 Penetration Piston.—A metal piston of circular cross-section having a diameter of 1.954 ± 0.005-in. (area = 3 sq. in.) and not less than 4-in. long. (See Fig. 1).

2.8 Loading Device.—A compression-type apparatus capable of applying a uniformly increasing load up to 10,000-lb. at a rate of 0.05-in. per min., used to force the penetration piston into the specimen.

2.9 Soaking Tank.—A soaking tank suitable for maintaining the water level 1-inch above the top of the specimens.

2.10 Drying Oven.—A thermostatically controlled drying oven capable of maintaining a temperature of 110 ± 5C (230 ± 9F) for drying moisture samples.

2.11 Miscellaneous.—Miscellaneous tools such as mixing pans, spoons, straightedge, filter paper, balances, etc.



Note: Where No dimension tolerance is given the dimension Shown is Approximate.

Fig. 1. — Bearing Ratio Test Apparatus.

Sample

3.1 Prepare a sample in accordance with PTM 106 (Method B) except that it shall weigh 75-lb. or more. Material passing the 2-in. sieve and retained on the 3/4-in. sieve shall be replaced with material passing the 3/4-in. sieve and retained on the No. 4 sieve as explained in the above PTM method. Select a representative portion weighing approximately 25-lb. for a moisture-density test and divide the remainder of the sample to obtain 3 representative portions weighing approximately 15-lb. each.

Moisture-Density Relation

4.1 Using the 25-lb. portion, determine the optimum moisture content and maximum dry density in accordance with AASHO T 99 (Method D).

Procedure

5.1 Normally, 3 specimens must be compacted so that their compacted densities range from 95 percent (or lower) to 100 percent (or higher) of the maximum dry density determined in Section 4.

NOTE 2.—Generally about 10, 30 and 65 blows per layer are suitable for compacting specimens 1, 2 and 3 respectively. More than 56 blows per layer are generally required to mold a CBR specimen to 100 percent of the maximum dry density determined by AASHO T 99 (Method D); this is due to the sample for the moisture-density test being reused, while the sample for the CBR specimen is mixed and compacted only once.

NOTE 3.—Some laboratories may prefer to test only one specimen, which would be compacted to maximum dry density at optimum moisture content as determined by AASHO T 99 (Method D).

5.2 Clamp the mold to the base plate, attach the extension collar and weigh to the nearest 0.01-lb. Insert the spacer disk into the mold and place a coarse filter paper on top of the disk.

5.3 Mix each of the three 15-lb. portions prepared in 3.1 with sufficient water to obtain the optimum moisture content determined in 4.

5.4 Compact one of the portions of soil-water mixture into the mold in equal layers to give a total compacted depth of about 5-in., compacting each layer with the lowest selected number of blows in order to give a compacted density of 95 percent or less of the maximum density.

5.5 Determine the moisture content of the material being compacted at the beginning and end of the compaction procedure (2 samples). Each moisture sample shall weigh at least 100 g. for fine-grained soils and 500 g. for coarse-grained soils.

5.6 Remove the extension collar, and using a straightedge, trim the compacted soil even with the top of the mold. Surface irregularities should be patched with small-sized material. Remove the spacer disk, place a coarse filter paper on the perforated base plate, invert the mold and compacted soil and place on the filter paper so the compacted soil is in contact with the filter paper. Clamp the perforated base plate to the mold and attach the collar. Weigh the mold and specimen to the nearest 0.01-lb.

5.7 Compact the other two 15-lb. portions in accordance with the procedure in 5.4 through 5.6, except that an intermediate number of blows per layer shall be used to compact the second specimen and the highest number of blows per layer shall be used to compact the third specimen.

Soaking

6.1 Place the swell plate with adjustable stem on the soil sample in the mold and apply sufficient annular weights to produce an intensity of loading equal to the weight of the subbase and base courses and surfacing above the tested material, ± 5-lb., but in no case shall the weight be less than 10-lb.

6.2 Place the tripod with dial indicator on top of the mold and make an initial dial reading.

6.3 Immerse the mold in water to allow free access of water to top and bottom of the specimen. During soaking, maintain the water level in the mold and the soaking tank approximately 1.0-in. above the top of the specimen. Soak the specimen 96 hrs. (4 days.)

NOTE 4.—A shorter immersion period (not less than 24 hours) may be used for soil-aggregate materials that drain readily if tests show that the shorter period does not effect the test results. For some clay soils, a soaking period greater than 4 days may be required.

6.4 At the end of 96 hr., make a final reading on the soaked specimens and calculate the swell as a percentage of the initial sample length:

$$\text{Percent swell} = \frac{\text{Change in length in in. during soaking}}{4.584 \text{ in.}} \times 100$$

6.5 Remove the specimens from the soaking tank, pour the water off the top and allow to drain downward for 15 min. Care shall be taken not to distrub the surface of the specimens during removal of the water. After draining, remove the surcharge weights and perforated plates.

NOTE 5.—**The specimens may be weighed after draining when it is desired to determine the average wet density of the soaked and drained material.**

Penetration Test

7.1 Application of Surcharge.—Place a surcharge of annular and slotted weights on the specimens equal to that used during soaking. To prevent displacement of soft materials into the hole of the surcharge weights, seat the penetration piston after one surcharge weight has been placed on the specimen. After seating the penetration piston the remainder of the surcharge weights shall then be placed around the piston.

7.2 Seating Piston.—Seat the penetration piston with a 10-lb. load, then set both the penetration dial indicator and the load indicator to zero.

7.3 Application of Load.—Apply the loads to the penetration piston so the rate of penetration is uniform at 9.05-in. per min. Record the load when the penetration is 0.025, 0.050, 0.075, 0.100, 0.150, 0.200, and 0.300-in. Load readings at penetrations of 0.400 and 0.500-in. may be obtained if desired.

NOTE 6.—**The moisture content of the upper 1.0-inch may be determined after testing if desired. Moisture samples shall weigh at least 100 g. for fine-grained soils and 500 g. for granular soils.**

Calculations

8.1 Stress-Strain Curve.—Plot the stress-strain (resistance to penetration-depth of penetration) curve for each specimen as shown in Fig. 2. In some instances, the initial penetration takes place without a proportional increase in the resistance to penetration and the curve may be concave upward. To obtain the true stress-strain relationships, correct the curve having a concave upward shape near the origin by adjusting the location of the origin as shown in Fig. 2. Determine the new location of the origin by extending the straightline portion of the stress-strain curve downward until it intersects the abscissa (See dashed Lines in Fig. 2).

8.2 California Bearing Ratio.—The corrected load values shall be determined for each specimen at 0.10 and 0.20-in. penetration. California Bearing Ratio values are obtained in percent by dividing the corrected load values at 0.10 and 0.20-in. by the standard loads of 1000 and 1500 psi, respectively, and multiplying these ratios by 100.

$$\text{CBR} = \frac{\text{Corrected load value}}{\text{Standard Load}} \times 100$$

8.2.1 The CBR is generally selected at 0.10-in. penetration. If the ratio at 0.20-in. penetration is greater, the test shall be rerun. If the check test gives a similar result, the ratio at 0.20-in. penetration shall be used.

8.3 Using the data obtained from the 3 specimens, plot the CBR-Dry Density as Molded relation as shown in Fig. 3. The design CBR may then be determined at the desired percentage of the maximum dry density--normally the minimum percentage compaction permitted by the agency's compaction specifications.

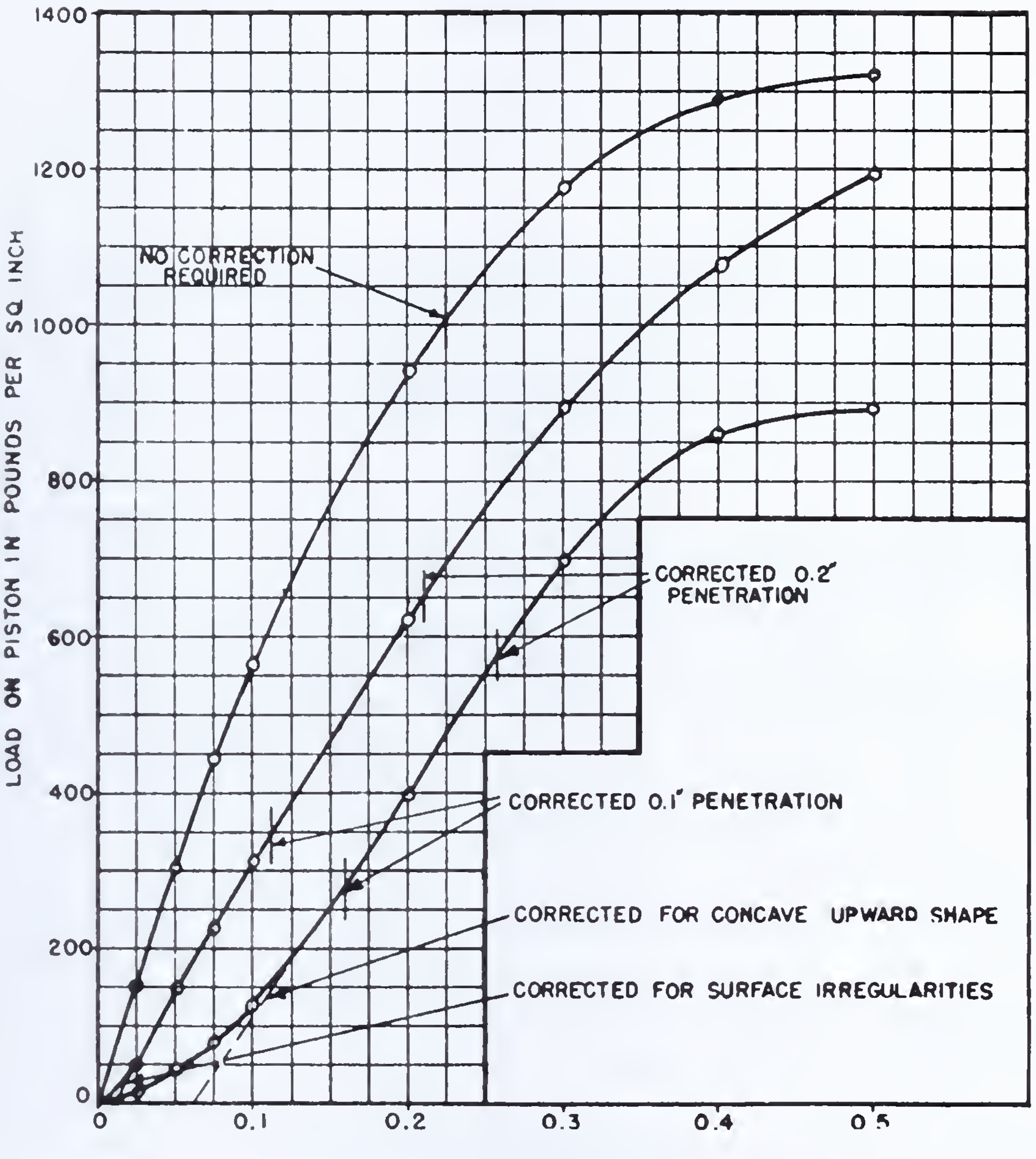
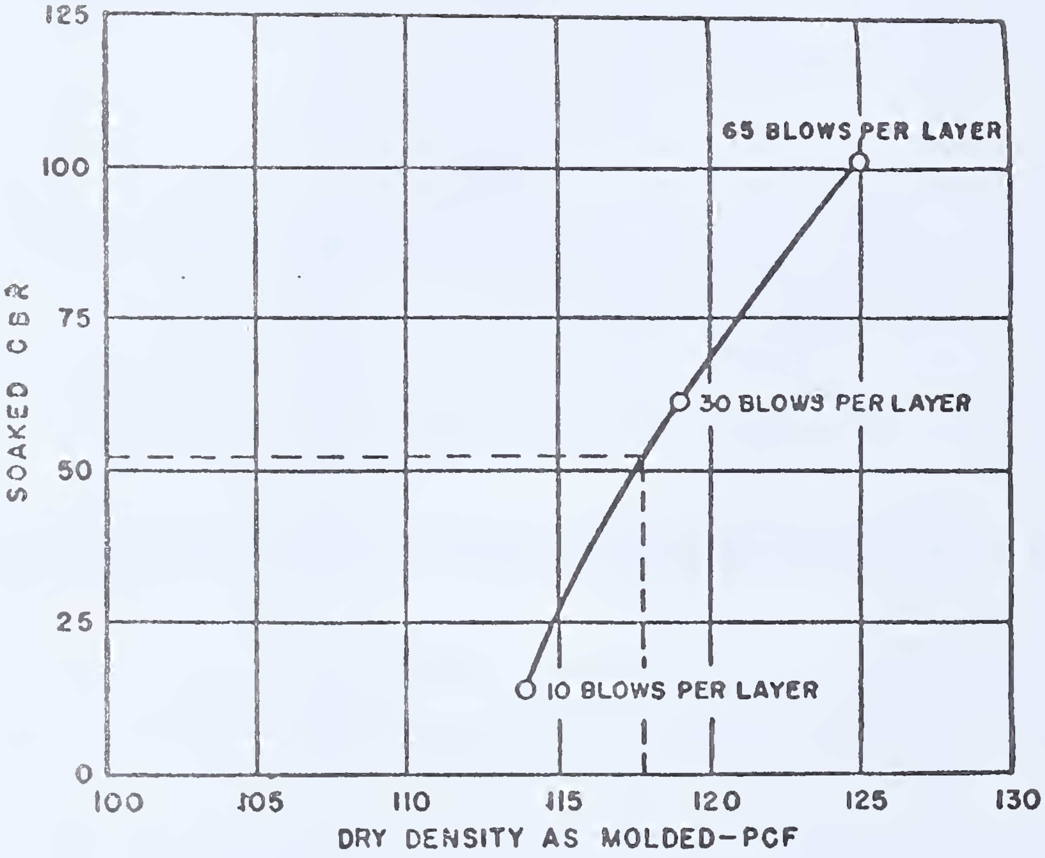


Fig. 2. – Correction of Load - Penetration Curves.



EXAMPLE

GIVEN: MAXIMUM DRY DENSITY BY T99-57 (METHOD D) = 124 P.C.F.
FIND: THE C B R AT 95 PERCENT OF THE ABOVE MAXIMUM DRY DENSITY.
SOLUTION: 95 PERCENT OF 124 P.C.F. = 117.8 P.C.F.
AT 117.8 P.C.F, THE C B R IS 52

FIG. 3.—*Dry Density Versus C B R*

Report

9.1 The report shall include the following information for each specimen:
9.1.1 Compaction effort (number of blows per layer)
9.1.2 Dry density as molded . . . . pct.
9.1.3 Moisture content ad molded. . . . . pct.
9.1.4 Swell (percent of original length) . . . . pct.
9.1.5 California Bearing Ratio . . . . pct.

End of Text PTM 113
Reference AASHO T-193

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 117
July, 1968
3 pages

Bureau of Materials Testing & Research

SPECIFICATIONS FOR
WIRE CLOTH SIEVES FOR TESTING PURPOSES

1. SCOPE

1.1 These specifications which are a modification of AASHO M 92 cover wire cloth sieves, for precision testing in the classification of materials according to the size (mechanical analysis, fineness, and particle size determinations). The sieves covered by these specifications are intended for general precision testing. Calibration of wire cloth sieves shall be in accordance with AASHO Designation M 92.

2. WIRE CLOTH SIEVES

2.1 Sieve Cloth

2.1.1 Fixed Ratio Series.—The openings of the sieve cloth of successive sieves of the standard series progress in the ratio $\sqrt[4]{2}:1$, and in selecting sieves from this series it is customary to take each sieve in a given range, every alternate sieve, or every fourth sieve.

2.1.2 Wire cloth for standard sieves shall be woven from brass, bronze, or other suitable wire, shall not be coated or plated, and shall be plain weave except that the cloth for sieves 63μ (No. 230) and finer may be twilled weave.

2.1.3 The average opening between the adjacent warp and the adjacent shoot wires, taken separately, shall conform to that given in column 3 of Table 1, within the "permissible variation in average opening" given in column 5. Column 4 gives the approximate equivalents in inches of the basic values in millimeters given in column 3. The average diameter of the warp and of the shoot wires, taken separately, of the cloth of any sieve shall be that given in column 8 of Table I, within the permissible variations given in footnote b of Table I. Column 9 gives the approximate equivalents in inches of the basic values in millimeters given in column 8. The maximum width of individual openings between adjacent warp and shoot wires shall not exceed the nominal width of opening by more than the permissible maximum variation in individual openings given in column 7 of Table I. An exception may be made, in the case of 8-in. sieves, if the total length of all the portions of rows of openings exceeding this maximum width is less than 4 in. in both the warp and the shoot directions, considered separately, and provided that the sieve is not rejected under Section 2.1.5. The permissible variation for not more than 5 per cent of the openings is given in column 6 of Table I.

2.1.4 Both the warp and shoot wires shall be crimped in such a manner that they will be rigid when in use.

2.1.5 There shall be no excessive variations in diameter in either warp or shoot wires in any sieve. Nor shall there be any punctures or other obvious defects in the cloth.

3. STANDARD 8-in. SIEVE FRAMES

3.1 Sieve Frames.—Frames for all sieves with openings 4.00 mm or less shall be the standard 8-in. size, except for the 3-in. sieves described in Section 4.1. Frames for sieves having nominal openings of less than 25.4 mm (1 in.) but greater than 4.00 mm may have frames either of the standard 8-in. size or of larger dimensions as may be specified in individual cases. Frames for sieves having nominal openings of 25.4 mm (1 in.) or more should be larger than the 8-in. standard.

TABLE I.-NOMINAL DIMENSIONS, PERMISSIBLE VARIATIONS, AND LIMITS FOR WIRE CLOTH OF STANDARD SIEVES.

(U. S. Standard Series (4th Root of 2 Ratio))

Sieve Designation		Sieve Opening		Permissible Variations in Average Opening, per cent	Permissible Variation for not more than 5 per cent of Openings, per cent	Permissible Maximum Variation in Individual Openings, per cent	Nominal Wire Diameter[b]	
Standard	Alternate	mm	in. (approximate equivalents)				mm	in. (approximate) equivalents)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
107.6 mm....	4.24 in.....	107.6	4.24	±3	+4	+5	6.40	0.2520
101.6 mm....	4 in.[a]......	101.6	4.00	±3	+4	+5	6.30	0.2480
90.5 mm....	3½ in......	90.5	3.50	±3	+4	+5	6.08	0.2394
76.1 mm....	3 in........	76.1	3.00	±3	+4	+5	5.80	0.2283
64.0 mm....	2½ in......	64.0	2.50	±3	+4	+5	5.50	0.2165
53.8 mm....	2.12 in.....	53.8	2.12	±3	+4	+5	5.15	0.2028
50.8 mm....	2 in.[a]......	50.8	2.00	±3	+4	+5	5.05	0.1988
45.3 mm....	1¾ in......	45.3	1.75	±3	+4	+5	4.85	0.1909
38.1 mm....	1½ in......	38.1	1.50	±3	+4	+5	4.59	0.1807
32.0 mm....	1¼ in......	32.0	1.25	±3	+4	+5	4.34	0.1665
26.9 mm....	1.06 in......	26.9	1.06	±3	+5	+6	3.90	0.1535
25.4 mm....	1 in.[a]......	25.4	1.00	±3	+5	+6	3.80	0.1496
*22.6 mm....	⅞ in.......	22.6	0.875	±3	+5	+6	3.50	0.1378
19.0 mm....	¾ in.......	19.0	0.750	±3	+5	+6	3.30	0.1299
*16.0 mm....	⅝ in.......	16.0	0.625	±3	+5	+6	3.00	0.1181
13.5 mm....	0.530 in....	13.5	0.530	±3	+5	+6	2.75	0.1083
12.7 mm....	½ in.[a].....	12.7	0.500	±3	+5	+6	2.67	0.1051
*11.2 mm....	7/16 in.......	11.2	0.438	±3	+5	+6	2.45	0.0965
9.51 mm...	⅜ in.......	9.51	0.375	±3	+5	+6	2.27	0.0894
*8.00 mm...	5/16 in.......	8.00	0.312	±3	+5	+6	2.07	0.0815
6.73 mm...	.265 in......	6.73	0.265	±3	+5	+6	1.87	0.0736
6.35 mm...	¼ in.[a].....	6.35	0.250	±3	+5	+6	1.82	0.0717
*5.66 mm...	No. 3½....	5.66	0.223	±3	+5	+10	1.68	0.0661
4.76 mm...	No. 4......	4.76	0.187	±3	+5	+10	1.54	0.0606
*4.00 mm...	No. 5......	4.00	0.157	±3	+5	+10	1.37	0.0539
3.36 mm...	No. 6......	3.36	0.132	±3	+5	+10	1.23	0.0484
*2.83 mm...	No. 7......	2.83	0.111	±3	+5	+10	1.10	0.0430
2.38 mm...	No. 8......	2.38	0.0937	±3	+5	+10	1.00	0.0394
*2.00 mm...	No. 10.....	2.00	0.0787	±3	+5	+10	0.900	0.0354
1.68 mm...	No. 12.....	1.68	0.0661	±3	+5	+10	0.810	0.0319
*1.41 mm...	No. 14.....	1.41	0.0555	±3	+5	+10	0.725	0.0285
1.19 mm...	No. 16.....	1.19	0.0469	±3	+5	+10	0.650	0.0256
*1.00 mm...	No. 18.....	1.00	0.0394	±5	+7½	+15	0.580	0.0228
841 μ........	No. 20.....	0.841	0.0331	±5	+7½	+15	0.510	0.0201
*707 μ........	No. 25.....	0.707	0.0278	±5	+7½	+15	0.450	0.0177
595 μ........	No. 30.....	0.595	0.0234	±5	+7½	+15	0.390	0.0154
*500 μ........	No. 35.....	0.500	0.0197	±5	+7½	+15	0.340	0.0134
420 μ........	No. 40.....	0.420	0.0165	±5	+12½	+25	0.290	0.0114
*354 μ........	No. 45.....	0.354	0.0139	±5	+12½	+25	0.247	0.0097
297 μ........	No. 50.....	0.297	0.0117	±5	+12½	+25	0.215	0.0085
*250 μ........	No. 60.....	0.250	0.0098	±5	+12½	+25	0.180	0.0071
210 μ........	No. 70.....	0.210	0.0083	±5	+12½	+25	0.152	0.0060
*177 μ........	No. 80.....	0.177	0.0070	±6	+20	+40	0.131	0.0052
149 μ........	No. 100....	0.149	0.0059	±6	+20	+40	0.110	0.0043
*125 μ........	No. 120....	0.125	0.0049	±6	+20	+40	0.091	0.0036
105 μ........	No. 140....	0.105	0.0041	±6	+20	+40	0.076	0.0030
*88 μ........	No. 170....	0.088	0.0035	±6	+20	+40	0.064	0.0025
74 μ........	No. 200....	0.074	0.0029	±7	+30	+60	0.053	0.0021
*63 μ........	No. 230....	0.063	0.0025	±7	+30	+60	0.044	0.0017
53 μ........	No. 270....	0.053	0.0021	±7	+30	+60	0.037	0.0015
*44 μ........	No. 325....	0.044	0.0017	±7	+30	+60	0.030	0.0012
37 μ........	No. 400....	0.037	0.0015	±7	+30	+60	0.025	0.0010

*These sieves correspond to those proposed as an International (ISO) Standard. It is recommended that wherever possible these sieves be included in all sieve analysis data or reports intended for international publication.

a. These sieves are not in the fourth root of 2 Series, but they have been included because they are in common usage.

b. The average diameter of the warp and of the shoot wires, taken separately, of the cloth of any sieve shall not deviate from the nominal values by more than the following

Sieves coarser than 595 μ .... 5 per cent
Sieves 595 μ to 125 μ .... 10 per cent
Sieves finer than 125 μ .... 15 per cent

Note.—All measurements of openings and wire diameters shall be made on the completed sieve.

3.2 Specifications for 8-in. Standard Frames.—Frames for all sieves with openings 5.66 mm or less shall be the standard 8-in. size, except that frames 3 in. in diameter may be used in the case of sieves 149 μ (No. 100) and finer, used primarily in the testing of paint pigments. The standard frames shall be circular, 8 in. (20.32 cm) in diameter. The height of the sieve from the top of the frame to the cloth shall be either about 2 in. (5 cm), or 1 in. (2.5 cm). Sieves having a height of 2 in. (5 cm) shall be designated as full-height sieves; those having a height of 1 in. (2.5 cm) as half-height sieves. The permissible variation on the mean inside diameter 3/16 in. below the top of the sieve shall be +1/32 in. The bottom of the sieve or "sieve skirt" shall be so constructed as to have an easy sliding fit in any sieve conforming to the above permissible variations, and in no case shall this outside diameter be less than 7.970 in. nor more than 8.000 in. Pans and covers shall be so made as to be interchangeable with standard sieves.

3.3 Mounting of Cloth in Frame.—The cloth shall be mounted on the frame without distortion, looseness, or waviness. To prevent the material being sieved from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder or so made that the material will not catch. The joint or fillet shall be so constructed in the 8-in. diameter sieve as to allow a minimum free sieving surface 7½ in. in diameter.

4. THREE-INCH SIEVES

4.1 Sieves 3 in. in diameter, used for testing paint pigments, shall be made from standard wire cloth 149 μ(No. 100) or finer. The sieve frames shall be circular 3 in. (7.6 cm) in inside diameter, and shall not vary from this by more than ± 0.16 in. (0.4 cm). The depth of the sieve from the top of the frame to the cloth shall be not less than 0.75 in. (1.9 cm).

4.2 The frames shall be constructed of first quality sheet brass in such a manner as to be permanently rigid. To prevent the material being sieved from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder or so made that the material will not catch.

4.3 Miscellaneous Special Sieves.—The use of special size frames for special purposes is not precluded; as, for example, sieves having a diameter other than 8 in. or the nesting sieves for field use. The use of special size frames should be discouraged where the standard 8-in. frames could be used, because the results are not necessarily comparable.

4.4 For some purposes, sieve frames larger than the standard 8-in. diameter may be either square or rectangular instead of circular, and for nominal openings 25.4 mm (1 in.) and coarser may be made of metal or hardwood.

5. LABEL MARKING

5.1 Each sieve (except the 3-in. sieve) shall bear a label marked with the following information:

5.2 For sieves 1.00 mm and coarser, show the sieve designation in millimeters and inches.

5.3 For sieves finer than 1.00 mm, show the sieve designation in microns and inches.

The corresponding U.S. Standard Sieve Number may be added for the convenience of the user.

End of Text PTM 117
Reference AASHO M 92

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 123
July, 1968
2 Pages

Bureau of Materials Testing & Research

METHOD OF TEST FOR

DETERMINATION OF MOISTURE IN SOILS BY MEANS OF A CALCIUM CARBIDE GAS PRESSURE METER

1. SCOPE

1.1 This method of test, which is in accordance with AASHO T 217 is intended to determine the moisture content of soils by means of a calcium carbide gas pressure (CCGP) moisture tester.

Note 1.—This method shall not be used on granular materials having particles large enough to affect the accuracy of the test—in general, any appreciable amount retained on a No. 4 sieve. If a six-gram sample is used, the sample should not contain any particles that will be retained on the No. 10 sieve.

2. APPARATUS

2.1 Calcium carbide gas pressure moisture meter
2.2 Tared scale
2.3 Two 1¼-inch (31.75 mm.) steel balls
2.4 Cleaning brush and cloth
2.5 Scoop for measuring calcium carbide reagent.

3. MATERIAL

3.1 Calcium carbide reagent.

Note 2.—The calcium carbide must be finely pulverized and should be of a grade capable of producing at least 2.25 cu. ft. of acetylene gas per pound of carbide.

4. PROCEDURE

4.1 When using the 26-gram size tester, place three scoops (approximately 24 grams) of calcium carbide and two 1¼-inch (31.75 mm.) steel balls in the larger chamber of the moisture tester. When using the six-gram size tester, place one level scoopful (approximately eight grams) of calcium carbide in the larger chamber of the tester.

4.2 Weigh a 26-gram sample (or a six-gram sample, if the small tester is being used) on the tared scale.

Note 3.—If the moisture content of the sample exceeds the limit of the pressure gauge (20 per cent moisture), a one-half size sample must be used and the dial reading must be doubled. Larger samples may be used for low moisture contents (5% or less). Two or three standard size samples can be used, depending upon the type of soil, and the dial reading must be divided by the number of samples used.

4.3 Place the soil sample in the cap of the tester and, with the pressure vessel in an approximately horizontal position, insert the cap in the pressure vessel and seal the unit by tightening the clamp, taking care that no carbide comes in contact with the soil until a complete seal is achieved.

4.4 Raise the moisture tester to a vertical position so that the soil in the cap will fall into the pressure vessel.

4.5 Shake the instrument vigorously so that all soil lumps will be broken up to permit the calcium carbide to react with all available free moisture. When steel balls are being used in the tester, the instrument should be shaken with a rotating motion so that the steel balls will not damage the instrument or cause soil particles to become embedded in the orifice leading to the pressure diaphragm.

Note 4.—Shaking should continue for at least 1 minute with granular soils and for up to 3 minutes for other soils so as to permit complete reaction between the calcium carbide and the free moisture. Time should be permitted to allow dissipation of the heat generated by the chemical reaction.

4.6 When the needle stops moving, read the dial while holding the instrument in a horizontal position at eye level.

4.7 Record the sample weight and dial reading.

4.8 With the cap of the instrument pointed away from the operator, slowly release the gas pressure. Empty the pressure vessel and examine the material for lumps. If the sample is not completely pulverized, the test should be repeated using a new sample.

4.9 The dial reading is the per cent of moisture by wet weight and must be converted to dry weight.

5. CALCULATION

5.1 The percentage of moisture by dry weight of the soil may be determined from the conversion curve (Fig. 1).

Note 5.—A conversion curve similar to Fig. 1 is normally supplied with the moisture tester. However, each moisture tester should be checked for accuracy of its gage, or for the accuracy of the conversion curve. Accuracy of the tester gage may be checked by using a calibration kit (obtainable from the tester manufacturer), equipped with standard gage; in case of discrepancy, the gage on the tester should be adjusted to conform with the standard gage. For checking the accuracy of the conversion curve, a calibration should be made for meter readings versus oven-dry moisture contents, using local soils. Also, additional testing may be necessary to extend the conversion curve (Fig. 1) beyond 44 per cent moisture content.

Note 6.—It may be more convenient for field use of the apparatus to prepare a table of moisture tester readings versus oven-dry moisture content for the moisture tester.

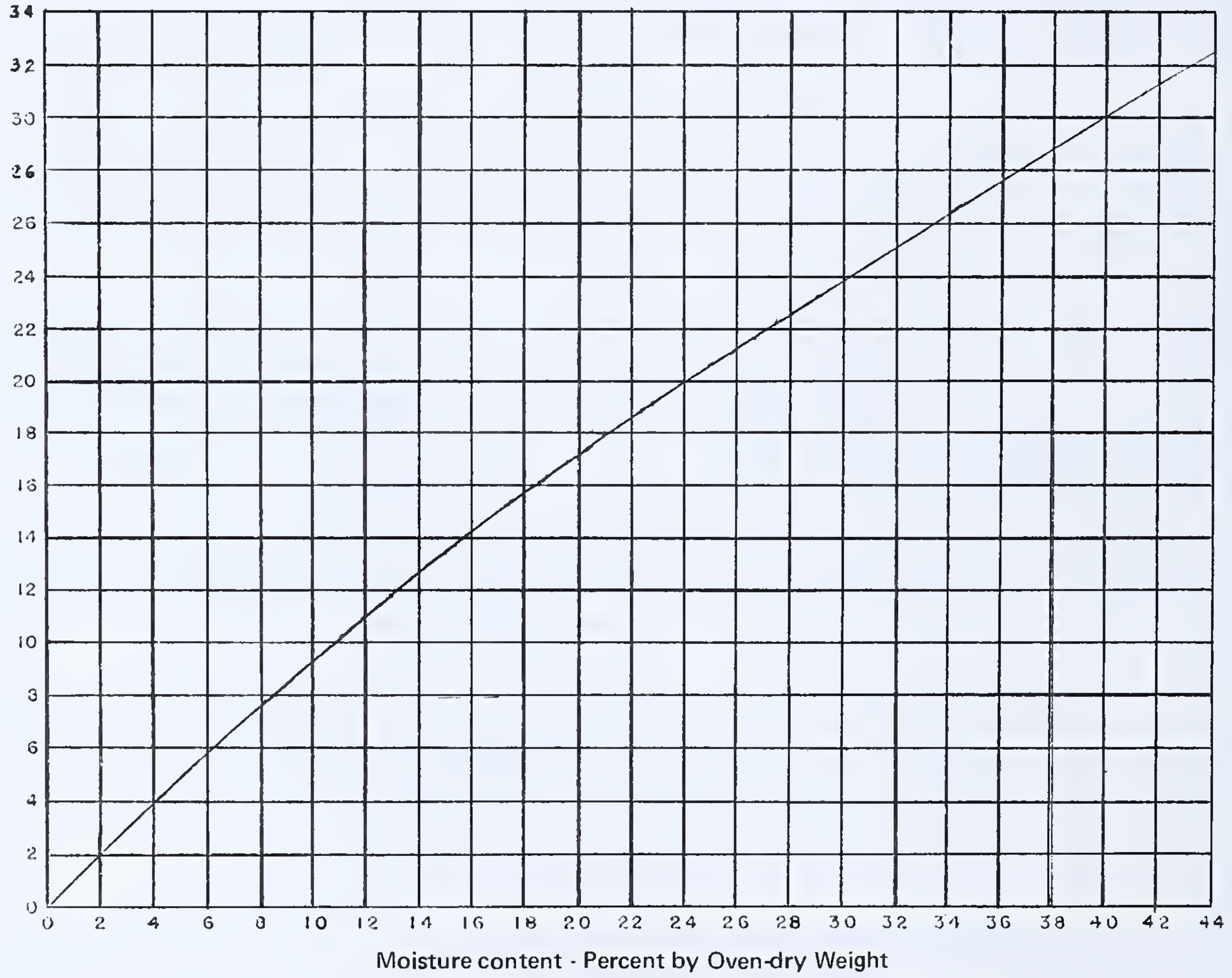


Fig. 1 - Conversion Curve for Moisture Tester Reading

End of Text PTM 123
Reference AASHO T 217

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 201
August 1968
1 Page

Bureau of Materials, Testing & Research

Method of Test for

WEIGHT PER GALLON OF PAINT

1. Scope

1.1 This method of test is intended for determining the weight per gallon of paint.

2. Apparatus

2.2 The apparatus shall consist of a smoothly finished aluminum, stainless steel, brass or plated cup provided with a snug-fitting, plug type cover having a small hole in its center. The capacity of the apparatus (filled to the top of the hole in the cover) at 23 ± 0.5 C. is 83.2 milliliters ± 0.1 milliliter. The inside of the bottom of the cup should be rounded. A convenient size for the apparatus is approximately 76 millimeters high by 38 millimeters in diameter; the hole in the cover should be provided.

3. Procedure

3.3 Pour the well-mixed paint, previously brought to a temperature of approximately 23 C., into the cup until it is nearly full, put on the cover, press it firmly in place and then wipe off the excess paint that exudes through the hole in the cover. Determine the weight of the paint in the cup in grams. Divide this figure by 10 to obtain the weight of the paint in pounds per gallon. This same procedure is used for pastes and semipastes except that particular care must be taken that no air pockets are trapped in the material. If the specific gravity of the material is required, multiply the weight per gallon by 0.12.

4. Alternate Procedures and Apparatus

4.4 Other methods employing suitable containers of known volumes and applicable procedures may be used provided equally accurate and reproducible results are obtained therewith. Such procedures and apparatus shall have been calibrated against the above standard and rechecked at periodic intervals.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 202
August 1968
1 Page

Bureau of Materials, Testing & Research

Method of Test for

MEASUREMENT OF DRY FILM THICKNESS OF PAINT

1. Scope

1.1 This method of test is intended for the measurement of the dry film thickness of paint.

2. Apparatus

2.1 Tooke Coating Inspection Gauge - The gauge utilizes a specially designed tungsten carbide cutting tip to scribe a precise microscopic V-groove through an applied paint film down to the substrate. This groove is sliced very smoothly and accurately at an angle of 45 degrees to the surface. When the groove is examined with the 50 power gauging microscope, film thickness and other characteristics of the applied paint system are readily observed and measured. The gauge is designed as a single unit with the illuminated microscope and the cutting tool assembly mounted on a polished rectangular aluminum case. Separate compartments in the case accommodate a brush-pen, "bench-marker" and small instrument wrenches. There are three (3) types of tips available for use with the Tooke Gauge. These vary only in width and slope of the incision which they make through the coating film.

The following table summarizes the abilities and limitations of each tip.

Tip	Maximum Coating Thickness	Accuracy of Thickness Determinations	One Division on Reticle Scale Represents
1X	50 mils	± 0.25 mils	1 mil
2X	20 mils	± 0.13 mils	0.5 mil *
10X	3 mils	± 0.025 mils	0.1 mil

3. Procedure

3.1 A small horizontal "bench mark" is applied to the surface with the brush-pen marker. A short scribe perpendicular to the "bench mark" is then made with the cutting tip. The guide studs maintain automatic alignment of the tip with the surface, while sufficient pressure is applied to the tip to cut through the paint into the substrate. The intersection of the "bench-mark" clearly delineates the top edge of the cut, thus facilitating film thickness measurement with the microscope reticle. Film thickness is obtained by counting scale divisions from left top edge of the groove down to the left edge of the exposed substrate.

*** NOTE - All instruments used by the department are equipped with a 2X cutting tips, therefore, each scale division is equivalent to 0.5 mil thickness.**

Commonwealth of Pennsylvania
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Pa. Test Method No. 203
August 1968
1 Page

Bureau of Materials, Testing & Research

Method of Test for

MEASUREMENT OF WET FILM THICKNESS OF PAINT

1. Scope

1.1 This method of test is intended for the measurement of the wet film thickness of paint.

2. Apparatus

2.1 Nordson Wet Film Thickness Gauge - Essentially, the gauge consists of a series of teeth of graduated clearances, calibrated in mils (thousandths of an inch), cut in the edges of a small square piece of metal as shown in the accompanying illustration.

3. Procedure

3.1 Rotate proper face to position. Use highest number mil face for heavy coatings, lowest number mil face for lightest coatings. Place gauge face square in fresh wet film and withdraw without tilting or sliding. The true wet film thickness lies between the highest step coated and the next highest step which did not coat. This thickness, when calculated on a volume solids basis, is indicative dry film thickness.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 204
March 1969
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

SAMPLING AND TESTING CALCIUM CHLORIDE

1. Scope

1.1 These methods cover procedures for sampling and testing calcium chloride. This method is a modification of AASHO Designation T–143.

2. Sampling

2.1 A mesh lot of calcium chloride shall be sampled for testing purposes as follows:

Not less than three containers shall be selected at random from the lot. Each of the containers shall be sampled by scraping aside the top layer to a depth of approximately 1 in. and taking 1 lb. samples by means of a sampling thief or other method which will insure a sample that is representative of a cross–section of the material in the container to a depth of at least 6 in. Precautions should be taken during the sampling operation to avoid exposing the sample unduly to atmospheric moisture. The individual samples shall be immediately and thoroughly mixed to form a representative composite sample of a material and stored in a sealed glass container or moisture–proof bag.

3. Sieve Analysis

3.1 Approximately 200g. of calcium chloride weighed to the nearest 0.1g. shall be sieved in accordance with the Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregate (Pa. Test Method No. 616), utilizing the 3/8 in., No. 4, and No. 30 sieves together with a bottom pan and a cover (sieving shall be completed within a period of approximately 1 minute). The sieve analysis shall be reported on the basis of the grading requirements specified in Section 4 of the Department of Highways Standard Specification for Calcium Chloride.

4. Total Calcium Chloride

4.1 Reagents

(a) EDTA solution, 0.1 M. Dissolve 37.22 grams of disodium Ethylenedinitrilotetraacetate dihydrate in water and dilute to one liter in a Volumetric Flask. This solution is standardized against 25ml of a standard calcium solution.

(b) Standard calcium solution. Dissolve 3.75 grams of analytical reagent grade calcium carbonate in a 400 ml beaker containing 50ml of water by adding 9ml of concentrated hydrochloric acid. Boil the solution to remove carbon dioxide, cool, transfer to a 500ml Volumetric Flask, and dilute to the mark with water. One ml of this solution contains 0.008275 grams of calcium chloride (calcium carbonate is 99.5% pure).

(c) Sugar

(d) Sodium hydroxide solution, 2 N

(e) Calcein modified indicator (G. Fredrick Smith Chemical Company, Columbus, Ohio).

4.2 Procedure

(a) Standardization of EDTA. Pipet 25ml of standard calcium solution into a 500ml Erlenmeyer Flask. Add 200ml distilled water. Add one drop of dilute nitric acid (HNO_3) (1:2) and approximately one gram of sugar. Swirl to dissolve the sugar. Add 40ml of 2 N sodium hydroxide (NaOH) to solution and then add ½ microspatula of calcein modified indicator. Titrate with 0.1 M EDTA to change in color from green to violet. Calcium chloride equivalent of one ml of EDTA computed as follows:

$$\frac{0.008275 \times 25}{\text{mls EDTA needed for titration}} = (\text{Grams } CaCl_2/\text{ml EDTA})$$

(b) Sample determination.

Pour the sample from the container as received on to a clean, dry surface. Rapidly scoop up small portions, from different parts of the pile to assure a representative sample, with a 3 dram vial and seal with a cork or stopper.

Weigh accurately 0.3 to 0.5g of sample into a 500ml Erlenmeyer Flask. Add 200ml distilled water, swirl to dissolve the sample. Add one drop of dilute nitric acid (HNO_3) (1:2) and proceed from this point as in standardization.

4.3 Calculation. Calculate the total calcium as percentage of $CaC1_2$, as follows:

$$\text{Percentage of } CaC1_2 = \frac{\text{ml of EDTA} \times \text{EDTA equivalent of } CaC1_2 \times 100}{\text{wt. of original sample in grams}}$$

5. Total Alkalinity and Magnesium Compounds

5.1 Analysis in accordance to AASHO Designation: T-143- or ASTM Designation: D-345-

6. Total Alkali Chlorides as Sodium Chloride

6.1 Analysis in accordance to AASHO Designation: T-143- or ASTM Designation: D-345-

7. Reference

AASHO Designation T-143.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 206
January, 1975
4 Pages

Bureau of Materials, Testing & Research

Method of Test for

ADHESION OF PAINT

1. Scope

1.1 This method describes a procedure for assessing the adhesion of coating films to substrates by applying and removing pressure-sensitive tape over cuts made in the film.

1.2 This method is suitable for use in the field or laboratory.

1.3 The substrates must be relatively unaffected by incisions made through the film.

1.4 This method is used to establish whether the adhesion of a coating to a substrate is at a generally adequate level. It does not distinguish between higher levels of adhesion for which more sophisticated methods are required.

2. Summary of Method

2.1 A lattice pattern with either six or eleven cuts in each direction is made in the film to the substrate, pressure-sensitive tape is applied over the lattice and then removed, and adhesion is evaluated by comparison with description and illustration.

3. Apparatus and Materials

3.1 Cutting tool – Sharp razor blade, scalpel, knife or other cutting device. It is of particular importance that the cutting edges be in good condition.

3.2 Cutting guide – If cuts are made manually (as opposed to a mechanical apparatus) a steel or other hard metal straight edge or template to ensure straight cuts.

3.3 Ruler – Tempered steel ruler graduated in 0.5 mm for measuring individual cuts.

3.4 Tape – Half-inch (12.5 mm) wide semi-transparent pressure-sensitive tape with adhesion strength of 36 ± 2.5 oz per inch width (40 ± 2.8 g/mm) when tested according to ASTM Method D1000, Testing Pressure-Sensitive Adhesion Coated Tapes for Electrical Insulation*. The adhesion shall not change by more than 5% of its mean value within 12 months. An adhesive composed of resin and 100% crude rubber is reported to meet these characteristics. The backing of the tape may consist of fiber-reinforced cellulose acetate**, unplasticised polyvinyl chloride or polyester film.

3.5 Rubber eraser on the end of a pencil.

3.6 Illumination – A light source and magnifying glass is helpful in determining whether the cuts have been made through the film to the substrate.

4. Test Specimens

4.1 When this method is used in the field, the specimen is the coated structure or article on which the adhesion is to be evaluated.

4.2 For laboratory use apply the materials to be tested to panels of the composition and surface conditions on which it is desired to determine the adhesion.

* *Annual Book of ASTM Standards, Part 29.*

** *Scotch brand acetate fiber tape No. 710 manufactured by Minnesota Mining and Manufacturing Co., St. Paul, Minn. has been found suitable for the purpose.*

5. Procedure

5.1 Select an area free from blemishes and minor surface imperfections. For tests in the field ensure that the surface is clean and dry. Extremes in temperature or relative humidity may affect the adhesion of the tape or the coating.

5.2 When conducting test on laboratory panels, place the panel on a firm base and under the illuminated magnifier make parallel cuts as follows:

5.2.1 For coatings having a dry film thickness up to and including 2.0 mils space the cuts 1 mm apart and make 11 cuts unless otherwise agreed upon.

5.2.2 For coatings having a dry film thickness greater than 2.0 mils space the cuts 2 mm apart and make 6 cuts.

5.2.3 Make all cuts 3/4 in. (20 mm) long. Cut through the film to the substrate in one steady motion using just sufficient pressure on the cutting tool to have the cutting edge reach the substrate. When making successive single cuts with the aid of a guide place the guide on the uncut area.

5.3 After making the required cuts brush the film lightly with a soft brush or tissue to remove any detached flakes or ribbons of coatings.

5.4 Examine the cutting edge and, if necessary, remove any flat spots or wire-edge by abrading lightly on a fine oil stone. Make the additional number of cuts at 90° to and centered on the original cuts.

5.5 Brush the area as before and inspect the incisions for reflection of light from the substrate. If the metal has not been reached make another grid in a different location.

5.6 Remove two complete laps of tape and discard. Remove an additional length at a steady (i.e. not jerked) rate and cut a piece about 3 in. (75 mm) long.

5.7 Place the center of the tape over the grid and smooth into place by a finger. To ensure a good contact with the film rub the tape firmly with the eraser on the end of a pencil. The color under the tape is a useful indication of when good contact has been made.

5.8 After not less than 60 seconds and not more than 5 minutes of application, remove the tape by seizing the free end and rapidly pulling it off at as close to an angle of 180° as possible.

5.9 Inspect the grid area for removal of coating from the substrate or from a previous coating using the illuminated magnifier. Rate the adhesion according to the following scale, using Figure 1 as a visual guide:

5. The edges of the cuts are completely smooth; none of the squares of the lattice is detached.

4. Small flakes of the coating are detached at intersections; less than 5 per cent of the area is affected.

3. Small flakes of the coating are detached along edges and at intersections of cuts. The area affected is 5-15 per cent of the lattice.

2. The coating has flaked along the edges and on parts of the squares. The area affected is 15-35 per cent of the lattice.

1. The coating has flaked along the edges of cuts in large ribbons and whole squares have detached. The area affected is 35-65 per cent of the lattice.

0. Flaking and detachment worse than grade 1.

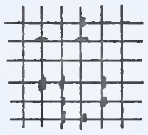
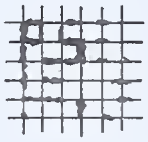
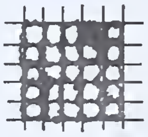
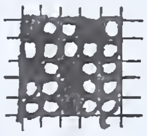
5.10 Repeat the test in two other locations on each test panel.

6. Report

6.1 Report the number of tests and their mean and range.
6.2 Report the substrate employed, the type of coating and the method of cure.
6.3 Recommend rating of 3 as minimum acceptable level of adhesion.

FIGURE 1

CLASSIFICATION OF ADHESION TEST RESULTS

Classification	Surface of cross-cuts area from which flaking has occurred. (Example for six parallel cuts.)
5 0%	NONE
4 Less 5%	
3 5% — 15%	
2 15% — 35%	
1 35% — 65%	
0	Greater than 65%

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 208
July 1976
1 Page

Bureau of Materials, Testing & Research

Method of Test for

DETERMINING THE PH OF WATER AT CONSTRUCTION LOCATIONS

1. Scope:

1.1 The purpose of this method is to present the procedure for determining the PH of water in the vicinity of future culvert and drainage pipe installations for determination of possible need of proper pipe coating.

2. Apparatus:

2.1 A Hach Model DR-EL Direct Reading Engineer's Laboratory, Catalog No. 1206, as manufacturer by the Hach Chemical Company, Ames, Iowa or the approved equal.

3. Procedure:

3.1 Rinse graduated cylinder thoroughly several times in water which sample is to be taken from.

3.2 After rinsing graduated cylinder thoroughly, accurately measure a 25.0 ml water sample by filling the graduated cylinder to the 25.0 ml mark. Pour sample into colorimeter bottle.

3.3 Add 1.00 ml of Wide Range indicator. Stopper and Shake to mix.

3.4 Fill a colorimeter bottle with some of the original water sample and place it in the light cell. Insert the Wide Range PH Meter Scale in the meter and use the 4084 color filter. Adjust the light control so that the meter reads at the far right end of the scale.

3.5 Place the colorimeter bottle containing the prepared sample in the light cell and read the scale. Read from right to left on the upper scale for green, blue and violet. Read from left to right on the lower scale for red, orange and yellow. Record PH value.

3.6 Repeat steps 3.1 thru 3.5 until three readings are obtained. Average three readings and record value.

4. Report:

4.1 A series of three readings shall be taken seasonaly and records of the average PH values maintained for future reference to determine proper pipe and type coating as outlined in Section 2.12.15.03 of the Design Manual.

4.2 A record of the date, time and approximate location of each survey shall also be kept.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 210
July 1977
2 Pages

Bureau of Materials, Testing and Research

Method of Test for Sampling and Testing Treated Wood Products

1. SCOPE

1.1 The purpose of this test is to outline the procedures for sampling and testing treated wood products.

2. DESCRIPTION OF MATERIAL

2.1 The procedures, herein, are designed to cover treated wood products for post mounted sign projects or other highway construction use.

3. SAMPLING PROCEDURES

3.1 Test for retention of preservatives shall be made on a sampling consisting of borings from not less that 20 pieces of lumber, representative of the lot but not less than one piece of lumber for each 1,000 board feet in the lot. When different sizes of lumber are encountered care should be taken to secure samples representative of all sizes in the lot.

3.2 Borings from southern yellow and ponderosa pine shall be taken from sapwood only. Borings from douglas fir and the other soft woods shall be taken from heartwood only.

3.3 No samples shall be taken closer than 3 feet from the end of any piece and the area where the sample is to be taken shall have any encrusted preservative removed. Boring shall be immediately and carefully placed in suitable containers to avoid all losses.

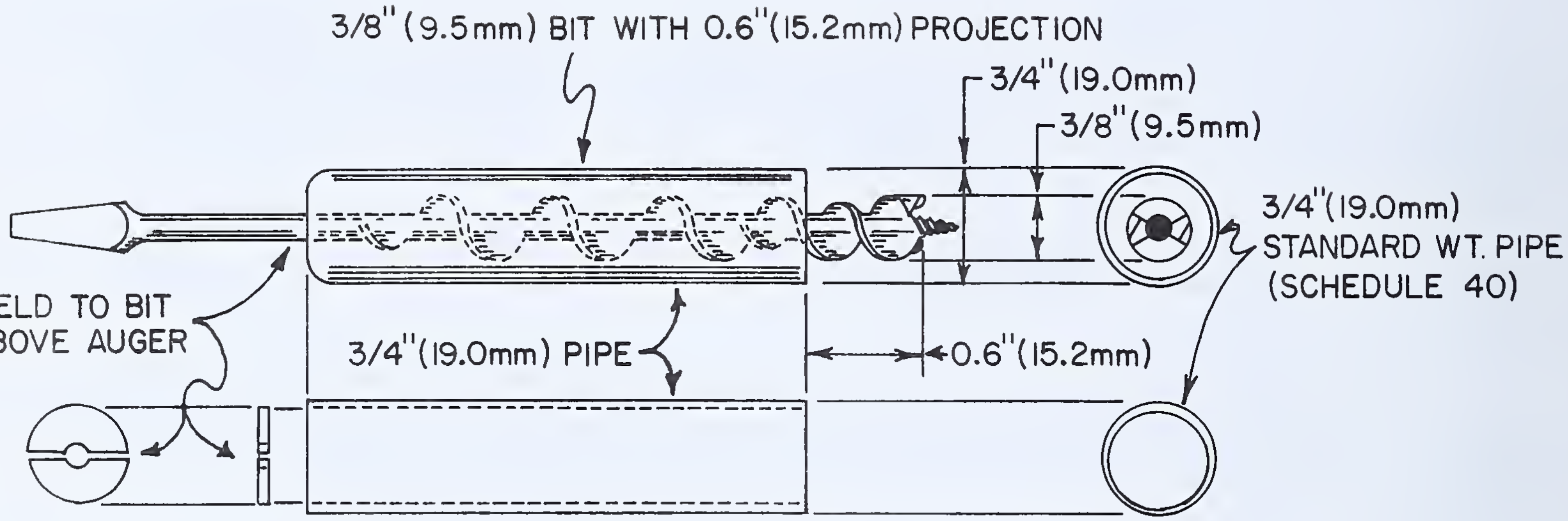
3.4 Borings shall be obtained using a hand brace and bit. Wood bit shall be 3/8 inch in diameter and shall be modified as shown in drawing to permit a depth pentration of 0.6 inches. All boring shall be made accurately to 0.6 inch is depth measured from the outside of the treated lumber. All shavings shall be retrieved from the hole and placed in a container.

3.5 Borings shall be submitted individually for testing. Tests will be conducted on composite samples prepared from the borings.

3.6 Boring holes shall be plugged immediately using latex or silicone caulking compound.

4. TESTING

4.1 Testing shall be performed in accordance with AWPA Test Method A9-70, A10-72 or A11-74. All samples will be tested at the Bureau of Materials, Testing and Research.



0.6"(15.2mm) PROJECTION DOES NOT INCLUDE FEED THREADS

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 312
October, 1973
1 Page

Bureau of Materials, Testing and Research

Method of Test for

Sampling and Reporting Neoprene Bridge Bearing Pads

1. Scope

1.1 This method covers the sampling of both Laminated and Non-Laminated Neoprene Bridge Bearing Pads and reporting test results.

2. Sampling

2.1 Laminated Neoprene Bridge Bearing Pads shall be sampled at the rate of one pad for every 20 pads or fraction of pads received. The total number of pads used on the project may be used to determine sampling requirements. If there is more than one laminated pad thickness used on the project, and more than one sample is required as dictated by the one for 20 requirement, the required number of samples should be representative of the thicknesses used.

2.2 Non-Laminated Bridge Bearing Pads shall be sampled at the rate of one pad for every 50 pads or fraction of pads received. The total number of pads used on the project may be used to determine sampling requirements. If there is more than one pad thickness used on the project, and more than one sample is required as dictated by the one for 50 requirement, the required number of samples should be representative of the thicknesses used.

2.3 The samples shall be taken only by Pennsylvania Department of Transportation personnel. Samples will be taken in accordance with PTM-1 at the ordering agency's facilities or project site and submitted to the Bureau of Materials Testing and Research.

2.4 Bulk shipments will be tested only if a written request is made to the Director, Bureau of Materials, Testing and Research.

2.5 It is the responsibility of the ordering agency to provide the required samples as determined by 2.1 and 2.2 above. The ordering agency is responsible for requesting sampling of shipments. The request should be made to the Chief Prestressed Plant Inspector or to the Director, Bureau of Materials, Testing and Research.

2.6 The Engineer may increase sampling requirements when found necessary.

3. Approval

3.1 Approval of Neoprene Bearing Pads will be granted after testing is completed and the pads are found to conform to the applicable specification. Testing and reporting normally requires 15 working days from receipt of samples at the Bureau of Materials, Testing and Research.

3.2 Notification of approval or rejection of the sampled bearing pads shall be by laboratory report.

3.3 The submission of Form TR-480, Certificate of Compliance of Elastomeric Materials shall be required. The submission of Form TR-480 shall be done in accordance with the latest C-letter directive.

4. Release of Bearing Pads for Placement

4.1 Until an acceptable laboratory report is received, the field inspector should not permit use of any neoprene bridge bearing pads.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 313
August, 1974
1 Page

BUREAU OF MATERIALS, TESTING AND RESEARCH

Method of Test for

SAMPLING
NEOPRENE COMPRESSION SEALS

1. Scope

1.1 This method covers the sampling of Preformed Neoprene Compression Seals for use in pavements or structures.

2. Sampling

2.1 Preformed Neoprene Compression Seals shall be sampled for approval at the rate of one (1) 5 foot length for each lot of seal used on a project. Lot numbers are to be repeatedly stenciled on the top of each seal, at three foot intervals.

2.1.1 At the time of installation an additional one (1) foot sample for each 500 feet or fraction of seal used will be taken.

2.1.2 All samples will be taken at the end of a run, or off the end of a reel. Samples will be taken in such a manner as to avoid unnecessary splicing or waste of material.

2.2 The samples shall be taken only by Pennsylvania Department of Transportation representatives. Samples shall be taken at the location where the seal becomes a physical part of the joint. This may be at the project site, fabrication shop, or other purchasing agencies' facilities and submitted to the Bureau of Materials, Testing and Research.

2.3 It is the responsibility of the purchasing agency to order sufficient material to cover sampling as determined by 2.1 above. The purchasing agency is responsible for requesting sampling of shipments.

2.4 The Engineer may increase sampling requirements when found necessary.

3. Approval

3.1 Approval to use the Preformed Neoprene Compression Seals will be granted after testing is completed and the material is found to conform to specification requirements. Testing and reporting will require 15 working days from receipt of samples at the Bureau of Materials, Testing and Research.

3.2 Notification of approval or rejection of the seal shall be by laboratory report.

4. Release of Seal for Replacement

4.1 Until acceptable laboratory report is received, the Field Inspector shall not permit the use of any Preformed Neoprene Compression Seals.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 402
March 1977
4 Pages

Bureau of Materials, Testing and Research

Method of Test for

DETERMINING MOISTURE OR DENSITY OF CONSTRUCTION MATERIALS BY USE OF NUCLEAR GAUGES

1. Scope

1.1 This method covers the determination of moisture content and density of soil and aggregates and the density of bituminous concrete by utilizing gamma radiation for density and neutron thermalization for moisture determination in the backscatter or direct transmission modes.

NOTE 1 – The direct transmission mode is still in an experimental stage and should not be used to determine material specification compliance.

2. Method

2.1 The density of a material under test may be determined by gamma backscatter or gamma direct transmission gauges.

2.1.1 In the backscatter mode, the density of a material under test is determined by placing a nuclear gauge containing a radioactive gamma source and a gamma detector on the surface of the material (Surface Density Count). The intensity of radiation detected is dependent on the density of the material under test. The radiation backscattered can be referred to a calibration chart or curve to determine material density. Since density as determined by a nuclear backscatter gauge is affected by chemical composition, the surface density readings must be corrected to counter act the chemical error. This is achieved by taking a surface test and then elevating the gauge to a predetermined height above the material by means of supplied spacers and repeating the test (Air Gap Density Count).

2.1.2 In the transmission mode, the density of a material under test is determined by placing a rod containing a radioactive gamma source or detector at some known depth below and perpendicular to the surface of the material being tested. The intensity of radiation detected is dependent on the depth of probe and the density of the material being tested. The detected radiation can be referred to a calibration chart or curve for the known depth to determine the density of the material to that depth without requiring a chemical correction.

2.2 The moisture content of a material under test may be determined by neutron thermalization in the backscatter mode only (Surface Count Only).

2.2.1 In the backscatter mode, the moisture content of a material under test is determined by placing a radioactive neutron source and a slow neutron detector on the surface of the material. The intensity of the radiation detected is dependent on the moisture content of the material under test. The count of slow neutrons backscattered can be referred to a calibration chart or curve to determined the moisture contained in the material.

3. Apparatus

3.1 Source. The source shall be an encapsulated and sealed radioisotopic material.

3.1.1 Dual purpose (Combination) gauges which determine moisture and density shall be capable of emitting both gamma and neutron radiation. Sources of this type can be RaBe, Cs, Am, etc.

3.2 Detector

3.2.1 Gamma detectors used in the determination of density shall be of the Geiger-Muller Tube, scintillator crystal, or proportional counter type.

3.2.2 Neutron detectors used to determine moisture content shall be any type of slow neutron detector such as borontriflouride, scintillator crystal, or fission chamber.

3.3 The readout for density or moisture shall be by means of a scalertimer, ratemeter, or direct readout.

3.4 Items 3.1 to 3.3 shall be enclosed in one or more housings of heavy duty construction which are dust proof and moisture proof. The source-detector housing for an asphalt density gauge shall be so constructed as to protect the contents from temperatures up to 350°F.

3.5 A reference standard of stable engineering material shall be provided to check equipment operation in all modes for which they are designed (Standard Blocks).

3.6 Apparatus Precision

3.6.1 Density Precision. Instrument precision for density determination shall be determined by the equation:

$$P_D = \frac{\text{Std. Dev.}}{S_D}$$

where:

P_D = precision for density, in pounds/cubic foot.

Std. Dev. = standard deviation at approximately 120 pcf (pounds/cubic foot) in cpm (counts/minute), and

S_D = slope of density calibration curve at approximately 120 pcf in cpm/pcf.

The value of P_D as determined above shall be less than 1.00 pcf.

3.6.2 Moisture Content Precision. Instrument precision for moisture content determination shall be determined by the equation:

$$P_M = \frac{\text{Std. Dev.}}{S_M}$$

where:

P_M = precision for moisture, in pounds/cubic foot.

Std. Dev. = standard deviation at approximately 15 pcf in cpm and,

S_M = slope of moisture calibration curve at 15 pcf in cpm/pcf.

The value of P_M as determined above shall be less than 0.50 pcf.

4. Procedure

4.1 Standardization. Equipment used to determine density or moisture must be standardized at least once a day, during usuage.

4.1.1 Warm up. Equipment shall be warmed up by connecting equipment in accordance with manufacturer's recommendations and counting either moisture or density for five to twenty minutes as required (See Publication No. 99).

4.1.2 Set up. Equipment shall be placed on the supplied standards being careful to follow the proper placement procedure as recommended by the manufacturer.

4.1.3 Taking Standard Count. A minimum of five-one minute counts shall be taken on the proper reference standard and these readings recorded. The average of the five counts shall then be computed. This average count shall not deviate from the supplied test standard by more than ± 5%. No more than one of the individual counts shall deviate from the average count by more than ± 2% of the average count.

NOTE 2 – The gauge standardization procedure should be conducted and recorded on TR-4276A at least once daily.

4.2. Test Site Preparation

4.2.1 Since surface texture has a large effect on density and moisture results, a smooth surface is necessary for proper testing. For soil testing, this shall be achieved by scraping and tamping surface with a surface preparation plate and filling in voids with native fines. On bituminous pavements, surface preparation consists of filling in voids if necessary with native fines or sand.

NOTE 3 –As a general rule most binder and base courses require surface preparation while most wearing courses do not. Surface preparation is necessary if there is a significant difference (2 to 3 pcf) between test results from a typical site that is prepared and a typical site that is not.

4.2.2 If following 4.2.1, a surface texture with all voids less than 1/8-inch cannot be achieved, a new surface should be prepared at a different site.

5. Testing

5.1 Seat gauge firmly at least ten feet from any construction equipment, at least twenty feet from any other nuclear equipment and at least one foot from any vertical projects. (curbs, trench walls, etc.)

5.2.1 Soils Testing. After proper warm-up procedures, take a single, one-minute reading for each of the following counts, surface density, moisture and air gap density. For direct transmission, no air gap count is required. Rotate the gauge 180° and repeat the procedure.

5.2.2 Bituminous Testing. Follow the same procedure as specified for soil testing with the exception that moisture counts are not required. Also, density tests on bituminous concrete should not be taken within two feet of a pavement edge unless the edge is butted against a vertical support such as an adjacent paving lane or shoulder. In this case the paving lane width will be considered to be two feet less than the actual width when selecting random test locations (See PTM No. 1). When a control strip is required, follow procedure as set forth in 6.2.

NOTE 4 – Always use the supplied drive pin when forming the test hole for direct transmission; never drive the source rod into a compacted material.

5.3 Determine the average cpm for each type of count and convert the readings to air gap density, or direct transmission density and moisture when required by referring to the proper ratio calibration chart or curve.

5.4 Record all readings on Nuclear Density Test Form No. TR 4276-A.

5.5 Calculate the percent compaction for the particular material being tested.

6. Control Strip Technique (For Bituminous Concrete)

6.1 Purpose. The objective of the control strip concept is to obtain the maximum density attainable under existing field conditions and employ this value as a target or standard for measurement of compaction compliance for specified work. Each control strip is to remain in place, unless otherwise specified by the engineer, and become a portion of the completed roadway.

6.2 Procedure

6.2.1 Average Air Gap Count Determination. The average air gap count will be determined prior to the start of control strip construction. The average air gap count will be the average of at least three air gap counts taken at random locations on the most recently completed material. The counting period for each reading may be ¼, ½ or 1 minute if the nuclear gauge is so equipped. Record the average air gap count on TR-4276B.

NOTE 5 – Since at the beginning of plant operation each day the first three truck loads cannot be used for control strip construction; (to allow for plant start-up) it is recommended that when possible the first three truck loads be placed and used for determining the average air gap count.

6.2.2 Conversion of 1.5 lb. Range into Counts. Determine 96% of the theoretical maximum density to the nearest 0.5 pound. Determine the difference between the chart ratio (CR) for this density and the chart ratio for the density 1.5 lbs. greater. This value shall be referenced as the Chart Ratio Difference. Multiply the chart ratio difference by the average air gap count, as determined in 6.2.1, to yield the count difference. The count difference is the change in gauge surface density counts necessary to produce a 1.5 lb. change in density. Record required information on TR-4276B.

6.2.3 Establishment of Optimum Rolling Pattern. The control strip shall consist of an area at least 400 square yards, and the thickness of the course shall be the same as specified in the contract. A location that would be a convenient test site between roller passes is selected. During the compaction of the control strip, the nuclear operator shall take a surface density reading at the selected location after each pass of the compaction equipment. A pass is defined as one coverage of the course being placed. The entire area of the control strip shall be compacted uniformly. The counting period for each reading may be ½ or ¼ minute if the nuclear gauge is so equipped; however; it must be the same counting period used to establish the average air gap count in 6.2.1. Compaction with each piece of equipment shall continue until the range of 3 successive readings is less than or equal to the count difference as determined in 6.2.2. The optimum number of passes for each piece of equipment shall be the pass with the lowest count of the 3 successive readings. In those cases where the counts continually increase with additional roller passes, proceed to the next compactor even if the range of 3 successive readings is greater than the count difference. Record all counts and plot the rolling pattern growth curve on TR-4276B.

NOTE 6 — **When a pneumatic-tire roller is used, nuclear density readings shall not be taken until after the second pass with this piece of equipment.**

6.2.4 Establishment of Target Density. Upon completing compaction of the control strip area, 10 random locations shall be selected in accordance with PTM No. 1. The control strip area shall be divided into 10 equal areas or sublets when selecting the random locations. At each location at least one surface density (B.S.) reading shall be taken and recorded on TR 4276B. The counting period must be one minute for these readings. Determine the average reading of the ten and record on TR 4276B. If the average air gap count determined in 6.2.1 was based on a counting period of less than one minute, adjust this count by multipling with the appropriate factor (Counting period ¼ minute — Factor is 4; counting period ½ minute — Factor is 2). Record adjusted air gap count in appropriate space on TR 4276B. Determine the air gap density ratio by dividing the average B.S. reading by the average A.G. reading. Determine air gap density in PCF by referring to appropriate gauge calibration chart. This density is the target density and should be recorded on TR 4276B.

7. References

ASTM D 2950
ASTM D 2922

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 410
May, 1974
2 Pages

Bureau of Materials, Testing and Research

Method of Test for

CHECKING OF PROPORTIONING BIN SCALES

1. Scope

1.1 This method of test covers the procedures for checking the sensitivity of bin scales used for the proportioning of bituminous and concrete materials and is applicable to bin scales of all capacities.

2. Apparatus

2.1 Weights. Ten fifty-pound weights accurate to within 1/30 oz. in fifty pounds as outlined by the National Bureau of Standards in their Class F requirements. These weights shall be certified every three years or less as may be required by the Pennsylvania Department of Agriculture, Bureau of Weights and Measures.

3. Procedure

3.1 These procedures shall be performed as directed by the Engineer at a minimum frequency of one per week while the plant is in operation.

3.2 Preliminary Inspection. This procedure shall be conducted prior to any scale checks.

3.2.1 Check the hopper to insure that it is empty and reasonably clean.

3.2.2 Check the scale weigh beams to insure that they are clean and their movement is not restricted.

3.2.3 Check the zero reading of the scale.

3.3 Load Scale Sensitivity Check

3.3.1 After assuring that the scale is properly zeroed, charge the hopper with a load equal to 50 percent of the batch weight.

3.3.2 Place test weights equal to 10% of scale capacity or 500 lbs., whichever is least, on the scale. Record the scale reading and remove the weights, again recording the scale reading to verify the initial loading.

3.3.3 Charge the hopper with the remainder of the batch and repeat 3.3.2.

3.4 Complete Scale Check. This method shall be performed at the start of the season, after any significant modification of the weigh system, or as deemed necessary by the Engineer.

3.4.1 Place test weights equal to ten percent of capacity or 500 pounds, whichever is least, on the scale. Record the scale reading and remove the weights, again recording the reading.

3.4.2 Charge the hopper with a test load equal to the previous scale reading.

3.4.3 Place an amount of test weights equal to the test weights of 3.4.1 on the scale, record the reading, and remove the weights, and again record the reading.

3.4.4 Repeat 3.4.2 and 3.4.3 until the maximum batch weight is reached.

4. Required Tolerances

4.1 The scale shall be considered accurate if the difference in scale reading produced by the addition or removal of test weights agrees with the value of the test load within 0.5 percent.

4.2 In the event that the tolerances are not met, the engineer shall be notified and the appropriate corrective measures taken.

Commonwealth of Pennsylvania
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Pa. Test Method No. 411
April, 1973
1 Page

Bureau of Materials, Testing & Research

Method of Test for

SAMPLING AND TESTING RIGHT-OF-WAY AND PROTECTIVE FENCING

1. Scope

1.1 The purpose of this test method is to outline procedures for sampling and testing Right-of-Way and Protective Fence in accordance with PTM #1, forms 410 and 408, standard drawings and any other applicable drawings or specifications currently used by the Pennsylvania Department of Transportation. The following is designed as a supplemental procedure for the above mentioned references and not as a replacement.

2. Description of Materials

2.1 The procedures herein are designed to cover all Right-of-Way and Protective Fencing components described in Sections 717 and 1016 of form 408 specifications of the Commonwealth of Pennsylvania, Department of Transportation.

3. Sampling Procedures

3.1 Samples shall be randomly secured in accordance with PTM #1, Section 2. Except for fabric, wire, and posts, 3 samples of each item shall be secured. Since the size of each lot will vary considerably, the particular sampling procedure under PTM #1, Section 2 shall be left to the discretion of the Field Engineer. Sample selection, however, should be based on Table #1 "Random Positions in Decimal Fractions."

3.2 All component parts and accessories for a particular job operation shall be in compliance with the appropriate specification before field installation.

3.3 In instances where all component parts are not submitted for test, the Field Engineer shall be responsible for assurance of a proper fit of the component parts.

3.4 Samples submitted for test shall conform to the following approximate sizes.
- a. Fabric — a full height sample, 2 feet wide.
- b. Post samples shall be 3 feet in length.
- c. Samples of wires shall be 3 feet in length.
- d. For caps, clamps, fasteners and all other accessories, 3 samples of each item shall be submitted.

4. Test Procedure

4.1 Physical testing shall be performed in accordance with the references listed in Section 1.1. Identification Form TR-447 shall indicate the type of fence submitted.

In the case of an item comprised of 3 samples, the physical measurement shall be an average of the 3 individual measurements, but no particular item shall be outside the specified tolerance.

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Pa. Test Method No. 412
April, 1973
1 Page

Bureau of Materials, Testing & Research

Method of Test for

SAMPLING AND TESTING OF BRIDGE DECK MATERIALS

1. Scope

1.1 The purpose of this test method is to outline procedures for sampling and testing bridge deck forms, angles, and accessories in accordance with the Pennsylvania Department of Transportation Form 408, the current issue of ASTM A-446, and any other applicable specification currently used by the Pennsylvania Department of Transportation. The following is designed as a supplemental procedure for the above mentioned references and not as a replacement.

2. Description of Materials

2.1 The procedures are designed to cover forms, angles, and end closures, and accessories used in the construction of bridge decking.

3. Sampling Procedures

3.1 Samples shall be randomly secured in accordance with PTM #1, Section 2.

3.2 One sample of each component part shall be submitted for each 25,000 square feet of bridge deck area.

3.3 Samples of bridge deck form shall be two (2) feet long and between two (2) feet and three (3) feet wide.

3.4 Angles and end closures submitted for test shall be two (2) feet in length.

3.5 There will be at least 12 screws in a sample.

3.6 Each sample will be accompanied by an identification form TR-447 which will indicate the grade of steel and in the case of screws the type and class of coating.

4 Test Procedures

4.1 Physical testing shall be performed in accordance with the current issue of ASTM A-446, except that the Base Metal Bend Test will not be conducted.

4.2 Gage thickness shall be determined using the coated metal.

4.3 The cross sectional area for tensile computations will be determined using the base metal thickness and milled width.

4.4 With the exception of end closures, approximately every tenth job sample by a particular manufacturer will be subjected to a chemical analysis.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 413
July, 1973
1 Page

Bureau of Materials, Testing and Research

Method of Test for

DEPTH OF STEEL EMBEDDED IN CONCRETE USING THE PACHOMETER METHOD

1. Scope

1.1 The purpose of this test method is to supply personnel in the field with an accurate and dependable means of determining the depth of steel reinforcing bars in concrete pavement by utilizing a pachometer.

2. Equipment

2.1 A pachometer of equal capabilities to the James Pachometer Model C-4946 will be utilized.

2.2 This type pachometer is capable of measuring steel up to depths of five (5) inches. It is a portable unit which measures steel reinforcing bar depth by means of magnetic detection of ferrous metal.

3. Test Procedures

3.1 The instrument should be turned on for several minutes prior to making depth measurements. This allows the battery output to stabilize.

3.2 After warm-up, adjust the meter pointer to exactly 100 (full-scale deflection). This adjustment must be made initially and checked frequently during testing to avoid meter drift.

3.3 Place the probe upon the concrete at the chosen location so that the axis of the probe is parallel to the reinforcing bar.

3.4 Slide the probe back and forth over the concrete until the meter indicates a minimum reading (i.e. maximum deflection to the left). Record this reading on the data sheet.

3.5 To determine the depth of the bar below the pavement surface, read the depth corresponding to the recorded meter reading from the appropriate calibration curve and record the depth on the data sheet.

4. Report

4.1 All data shall be recorded on form # TR-4344.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 414
November, 1976
1 Page

Bureau of Materials, Testing and Research

Method of Test for

OBTAINING SAMPLES OF PULVERIZED CONCRETE FOR CHLORIDE ANALYSIS

1. Scope

1.1 This method describes the procedure for obtaining samples of pulverized portland cement concrete for chloride analysis. Samples are obtained using a rotary-impact type drill.

2. Equipment

2.1 A rotary impact type drill with a depth indicator and 3/4" drill bits.

2.2 Sample containers capable of maintaining the sample in an uncontaminated state.

2.3 Spoons of adequate size to collect the sample from the drilled holes.

2.4 A "blow out" bulb or other suitable means of removing excess pulverized material from the hole prior to re-drilling operations.

2.5 A pachometer with equal capabilities to the James Pachometer Model C-4946.

3. Procedure

3.1 The number of samples taken in each lane shall be computed, in accordance with PTM #415, "Method of Sampling Miscellaneous Materials", as the cube root ($\sqrt[3]{\quad}$) of the length of the lane in feet. Not less than five (5) samples per lane shall be taken.

3.2 The location of the samples shall be determined in accordance with PTM #1, "Probability Sampling".

3.3 An approximate five (5) gram sample shall be taken one-half inch directly above a rebar as follows:

3.3.1 Determine bar location and depth according to PTM #413, "Depth of Steel Embedded in Concrete Using the Pachometer Method".

NOTE – When bituminous concrete overlays are present, a section of the overlay large enough to effectively accomodate the pachometer probe shall be removed prior to application of this test method.

3.3.2 Set the rotary hammer's depth indicator so that it will drill to one-half inch above the rebar.

3.3.3 Using a 3/4" drill bit, drill until the depth indicator seats itself on the concrete surface.

3.3.4 Thoroughly clean the drilled hole and surrounding area utilizing the "blow out" bulb or other suitable means.

3.3.5 Reset the depth indicator to permit one-half inch additional drilling.

3.3.6 Pulverize the concrete until the depth indicator again seats itself on the concrete.

3.3.7 Collect the material remaining in the hole using a spoon and place in the sample container.

3.4 Chloride ion samples shall be identified as to location and forwarded with Form TR 447 to the Bureau of Materials, Testing and Research for analysis.

3.5 Care should be taken to patch all holes with a material similar to and compatible with the roadway surface being patched.

Commonwealth of Pennsylvania
Department of Transpoortation

Pa. Test Method No. 415
July, 1973
4 Pages

Bureau of Materials, Testing & Research

Method of Test for

SAMPLING MISCELLANEOUS MATERIALS

1. Scope

1.1 This method of sampling outlines the procedures for selecting quantities of miscellaneous materials for quality assurance testing. Miscellaneous Materials shall be considered as those materials not covered by any other PTM or those described in the Materials Assurance Manual, Item 9 – Miscellaneous Materials.

2. Sample Selection

2.1 Samples shall be selected in a random manner in accordance with PTM 1.

2.2 The number of samples constituting a lot shall be computed as the cube root $\sqrt[3]{\quad}$ of the number of units or quantity of miscellaneous material to be used on the project.

> Example – If 27,000 miscellaneous bolts of a given size were to be used on a structure, the total number of samples to be taken in accordance with PTM 1 would be $\sqrt[3]{27{,}000}$ or 30 bolts.

2.3 If material is sent to a project site in packaged groups (i.e. cartons or kegs), the number of samples computed in Section 2.2 shall be choosen from the $\sqrt[3]{\quad}$ of the number of packaged groups.

> Example – If the 27,000 bolts in Section 2.2 were shipped in 27 cartons, the 30 bolts would be selected from $\sqrt[3]{27}$ or from 3 cartons; thus, 10 bolts would be choosen from each of 3 cartons in the random fashion described in PTM #1.

2.4 Dimensions or weights of miscellaneous units shall be checked for compliance against plans and specifications at the sampling site. Materials requiring physical or chemical tests should be sampled in accordance with 2.1 and 2.2 above and forwarded to the Bureau of Materials, Testing and Research, identified on Form 447 as "Verification Samples."

USE OF CUBE ROOT TABLES

If # of Items to be Samples is	n =	Answer in Column #	Remarks
1 – 100	# of items	1	use answer as is
100 – 1000	$\frac{\#\text{ of items}}{10}$	2	use answer as is
1000 – 10,000	$\frac{\#\text{ of items}}{100}$	3	use answer as is
10,000 – 100,000	$\frac{\#\text{ of items}}{1000}$	1	multiply answer by 10
100,000 – 1,000,000	$\frac{\#\text{ of items}}{10{,}000}$	2	multiply answer by 10

Example

27,000 items

Since it lies between 10,000 and 100,000

$$n = \frac{27{,}000}{1000} = 27$$

using column 1, $\sqrt[3]{27} = 3$

multiplying by 10, $\sqrt[3]{27{,}000} = 3 \times 10 = 30$

Table of Cube Roots

n	1	2	3	n	1	2	3
n	$\sqrt[3]{n}$	$\sqrt[3]{10n}$	$\sqrt[3]{100n}$	n	$\sqrt[3]{n}$	$\sqrt[3]{10n}$	$\sqrt[3]{100n}$
1	1.000	2.154	4.641	50	3.684	7.937	17.09976
2	1.259	2.714	5.848	51	3.708	7.989	17.21301
3	1.442	3.107	6.694	52	3.732	8.041	17.32478
4	1.587	3.419	7.368	53	3.756	8.092	17.43513
				54	3.779	8.143	17.54411
5	1.709	3.684	7.937	55	3.802	8.193	17.65174
6	1.817	3.914	8.434	56	3.825	8.242	17.75808
7	1.912	4.121	8.879	57	3.848	8.291	17.86316
8	2.000	4.308	9.283	58	3.870	8.339	17.96702
9	2.080	4.481	9.654	59	3.892	8.387	18.06969
10	2.154	4.641	10.00000	60	3.914	8.434	18.17121
11	2.223	4.791	10.32280	61	3.936	8.480	18.27160
12	2.289	4.932	10.62659	62	3.957	8.527	18.37091
13	2.351	5.065	10.91393	63	3.979	8.572	18.46915
14	2.410	5.192	11.18689	64	4.000	8.617	18.56636
15	2.466	5.313	11.44714	65	4.020	8.662	18.66256
16	2.519	5.428	11.69607	66	4.041	8.706	18.75777
17	2.571	5.539	11.93483	67	4.061	8.750	18.85204
18	2.620	5.646	12.16440	68	4.081	8.793	18.94536
19	2.668	5.748	12.38562	69	4.101	8.836	19.03778
20	2.714	5.848	12.59921	70	4.121	8.879	19.12931
21	2.758	5.943	12.80579	71	4.140	8.921	19.21997
22	2.802	6.036	13.00591	72	4.160	8.962	19.30979
23	2.848	6.126	13.20006	73	4.179	9.004	19.39877
24	2.884	6.214	13.38866	74	4.198	9.045	19.48695
25	2.924	6.299	13.57209	75	4.217	9.085	19.57434
26	2.962	6.382	13.75069	76	4.235	9.125	19.66095
27	3.000	6.463	13.92477	77	4.254	9.165	19.74681
28	3.036	6.542	14.09460	78	4.272	9.205	19.83192
29	3.072	6.619	14.26043	79	4.290	9.244	19.91632

Table of Cube Roots (cont.)

n	1	2	3	n	1	2	3
n	$\sqrt[3]{n}$	$\sqrt[3]{10n}$	$\sqrt[3]{100n}$	n	$\sqrt[3]{n}$	$\sqrt[3]{10n}$	$\sqrt[3]{100n}$
30	3.107	6.694	14.42250	80	4.308	9.283	20.00000
31	3.141	6.767	14.58100	81	4.326	9.321	20.8299
32	3.174	6.839	14.73613	82	4.344	9.359	20.16530
33	3.207	6.910	14.88806	83	4.362	9.397	20.24694
34	3.239	6.979	15.03695	84	4.379	9.435	20.32793
35	3.271	7.047	15.18294	85	4.396	9.472	20.40828
36	3.301	7.113	15.32619	86	4.414	9.509	20.48800
37	3.332	7.179	15.46680	87	4.431	9.546	20.56710
38	3.361	7.243	15.60491	88	4.447	9.582	20.64560
39	3.391	7.306	15.74061	89	4.464	9.619	20.72351
40	3.419	7.368	15.87401	90	4.481	9.654	20.80084
41	3.448	7.428	16.00521	91	4.497	9.690	20.87759
42	3.476	7.488	16.13429	92	4.514	9.725	20.95379
43	3.503	7.547	16.26133	93	4.530	9.761	21.02944
44	3.530	7.605	16.38643	94	4.546	9.795	21.10454
45	3.556	7.663	16.50964	95	4.562	9.830	21.17912
46	3.583	7.719	16.63103	96	4.578	9.864	21.25317
47	3.608	7.774	16.75069	97	4.594	9.898	21.32671
48	3.634	7.829	16.86865	98	4.610	9.932	21.39975
49	3.659	7.883	16.98499	99	4.626	9.966	21.47229
50	3.684	7.937	17.09976	100	4.641	10.00000	21.54435

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 419
September, 1975
2 Pages

Bureau of Materials, Testing and Research
Method of Test for

DEPTH OF STEEL EMBEDDED IN CONCRETE BRIDGE DECKS USING THE PACHOMETER METHOD

1. Scope

1.1 The purpose of this test method is to supply personnel in the field with an accurate and dependable means of determining the depth of steel reinforcing bars in bridge decks by utilizing a pachometer.

2. Equipment

2.1 A pachometer of equal capabilities to the James Pachometer Model C-4946 will be utilized.

2.2 This type pachometer is capable of measuring the depth of reinforcing steel to depths of five inches within ± 1/8 inch overall accuracy. It is a portable unit which measures steel reinforcing bar depth by means of magnetic detection of ferrous metal.

3. Test Site Locations

3.1 When possible the entire bridge shall be tested as one area. On large bridges, the data from areas between expansion devices shall be recorded on separate data sheets.

3.2 The bridge deck area shall be marked in a grid pattern such that readings are taken approximately every five feet transversely and longitudinally over the entire deck area. The starting point should be indicated on the data sheet sketch.

3.3 Record every meter reading and/or corresponding depth in the appropriate space on the data sheet.

4. Test Procedures

4.1 The instrument should be turned on for several minutes prior to making depth measurements. This allows the battery output to stabilize.

4.2 After warm-up, adjust the meter pointer to exactly full-scale deflection. This adjustment must be made initially and checked frequently during testing to avoid meter drift.

4.3 Place the probe upon the concrete at the chosen location so that the probe is parallel to the reinforcing bar of the main steel.

4.4 Slide the probe back and forth over the concrete until the meter indicates a minimum reading (i.e. maximum deflection to the left). Record this reading on the data sheet.

4.5 To determine the depth of the bar below the pavement surface, read the depth corresponding to the recorded meter reading from the appropriate calibration curve and record the depth on the data sheet.

5. Report

5.1 The final report will include both the data sheet and Bridge Description Supplement Sheet.

5.2 The data sheet sketch should include the following:

1. General shape of bridge
2. Direction of traffic flow and arrow indicating North
3. Location of starting point
4. Location and orientation of expansion devices
5. Direction in which main steel lies.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No.421
November, 1976
2 Pages

Bureau of Materials, Testing and Research

Method of Test for

RE-BAR CORROSION IN BRIDGE DECKING

1. Scope

1.1 This method describes the procedure to be used in determining the extent of corrosion in steel-reinforced concrete bridge decks by measuring the electrical potential of the corroded steel.

2. Equipment

2.1 DC millivoltmeter with 0-1000mv range precise to the nearest 1 mv.
2.2 Two spools of #18 or #20 gauge stranded copper wire, each fifty feet in length.
2.3 Wetting agent.
2.4 Copper sulfate dispensing unit with open-cell sponge pad. (See Figure 1).

NOTE: Dimensions may differ from those shown in the sketch below without affecting the test results.

The foam rubber pad is secured to the dispensing unit to completely encompass the base of the tube. A rubber band or masking tape should hold the pad in place. This produces a "sponge" type application of the solution to the pavement surface.

The copper sulfate solution is made by dissolving Cupric Sulfate crystals in tap water until a saturated condition is reached.

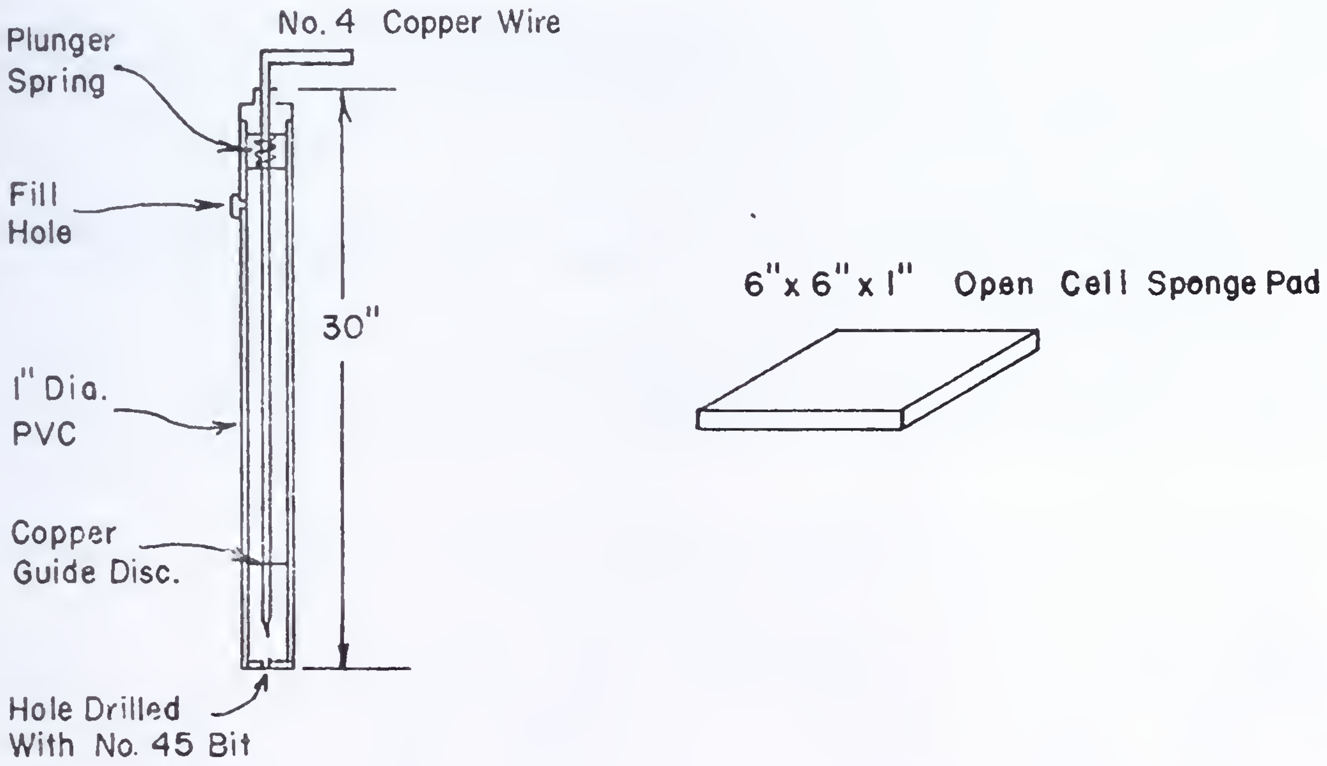

Figure 1. Sketch of Typical Dispensing Unit and Foam Rubber Pad.

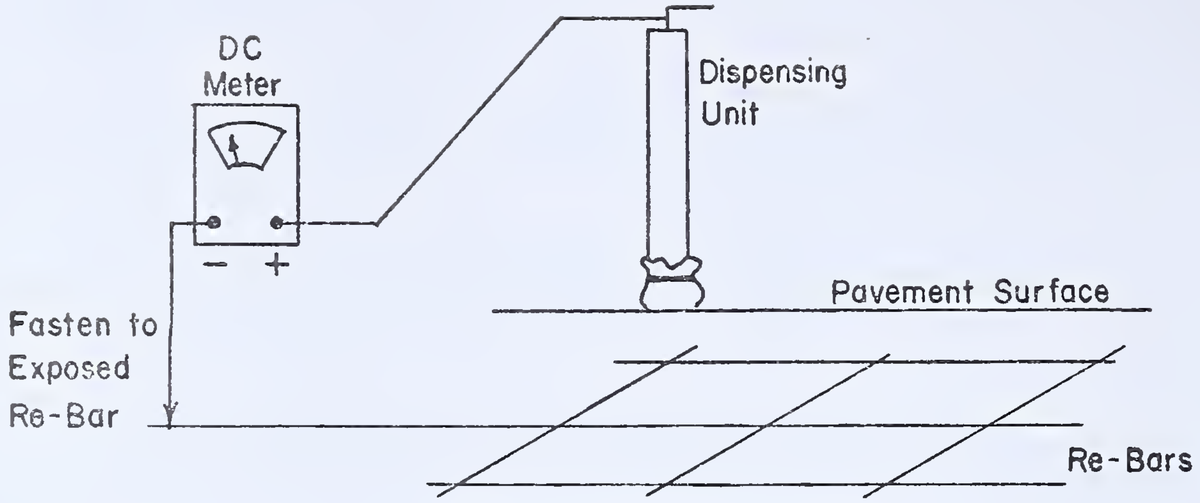

Figure 2. Test Set Up

The wetting agent — In order to standardize the potentail drop through the concrete portion of the circuit, an electrical contact solution shall be used to wet the electrical junction between the dispensing unit and the pavement. One such solution is composed of a mixture of 95 milliliters of wetting agent (Dioctyl Sodium Sulfosuccinate which is available under the Registered Trademark of: "Aerosol" OT Clear, 75%) thoroughly mixed with 5 gallons (19 liters) of potable water. Under working temperatures of less than about 50°F (10°C), about 15% by volume of either isopropyl or denatured alcohol must be added to prevent clouding of the electrical contact solution, since clouding may inhibit penetration of water.

3. Method of Test

3.1 A bridge span shall be tested according to a grid pattern.

3.2 Test locations shall approximate the following:

A reading shall be taken within five (5) feet of the end of each bridge span and within one (1) foot of the edge of the outside lane. Thereafter, readings shall be taken longitudinally at four (4) foot intervals and transversely at four (4) foot intervals across both the outside and inside lanes.

3.3 The copper sulfate half cell must be grounded to a portion of a reinforcing bar so that there is electrical continuity between all bars of the span under test. (See Figure 2).

3.4 Wetting agent shall be applied to each test location.

3.5 Connect the test device as shown on the above sketch, lift the plunger on the dispensing unit to thoroughly soak the foam pad, and place the probe on the test location.

3.6 When the probe is placed on the concrete, the readings shall be taken as soon as the meter stabilizes. Readings shall be considered void if the meter does not stabilize within 10 seconds.

3.7 A record of the millivoltage readings obtained shall be maintained for each bridge deck surveyed.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 501
March 1971
1 Page

Bureau of Materials Testing & Research

Method of Test for

DETERMINATION OF FINENESS MODULUS OF FINE AGGREGATES

1. Scope

1.1 The procedure, as outlined, is a modification of AASHO Designation: M 6- , Uniformity of Grading, and is used for determining the Fineness Modulus of fine aggregates.

2. Apparatus

2.1 The apparatus shall be as specified in PTM 616.

3. Procedure

3.1 The sieve analysis of the given fine aggregate shall be conducted in accordance with PTM 616.

4. Calculations

4.1 The calculations for the Fineness Modulus of a given sample of fine aggregate shall be made upon completion of the sieve analysis.

4.2 All of the sieves that are necessary for the determination of the Fineness Modulus shall be included, and are as follows: No. 100, No. 50, No. 30, No. 16, No. 8, and the No. 4 sieve.

4.3 Determine the percentage retained on each of the specified sieves by subtracting the percentage passing a given sieve from 100 percent. Percentages shall be rounded off to the nearest whole number (Note 1).

4.4 Obtain the Fineness Modulus by adding the total percentages of a sample of the aggregate retained on each of the specified series of sieves, and dividing the sum by 100.

5. References

5.1 AASHO: M6

5.2 PTM 616

NOTE 1. An example of a sieve analysis and the procedure used for calculating the Fineness Modulus is shown below.

(Column 1) Sieve Size	(Column 2) Weight Passing	(Column 3) Percent Passing	(Column 4) Percent Retained
No. 100	12.7	2	98
No. 50	79.6	16	84
No. 30	223.9	44	56
No. 16	376.7	74	26
No. 8	458.7	90	10
No. 4	502.1	99	1
No. 3/8"	508.5	100	(Not included in calculations)

$$\text{Fineness Modulus} = \frac{\text{Total of Column 4}}{100} = 2.75$$

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 503
June, 1973
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

SURFACE MOISTURE IN AGGREGATES

1. Scope

1.1 This method of test which is a modification of ASTM C 566 covers the determination of the percentage of evaporable moisture (surface moisture) in a sample of aggregate by drying. (NOTE 1).

NOTE 1 – Either Pa. Test Method No. 123 or Pa. Test Method No. 504 is an acceptable alternate for determining the surface moisture in fine aggregate.

2. Apparatus

2.1 Balance. The balance or scale shall have a sensitivity of not less than 0.1 percent of the weight of the sample being tested.

2.2 Source of Heat. A suitable source of heat such as an electric or gas hot plate, electric heat lamps, or a ventilated oven capable of maintaining the temperature surrounding the sample at 212 F to 230 F (100 C to 110 C).

2.3 Sample Container. A metal container, such as a pie pan or biscuit pan for use in drying the aggregate.

2.4 Stirrer. A metal spoon or spatula of convenient size or a piece of heavy wire fashioned into a suitable shape for stirring.

3. Sample

3.1 Carefully secure a sample representative of the moisture content in the supply being tested.

3.2 The sample shall be reduced in accordance with PTM 625 until the approximate weight of the sample for testing is as follows:

Penna. Size Aggregate	Approximate Weight in Grams
No. 2	3000
No. 2B	4000
No. 3A	8000
1NS	2000
2NS	4000
Fine Aggregate	500

NOTE: In no case, however, should the selection of a sample of a predetermined weight be attempted.

4. Procedure

4.1 Weigh the sample to the nearest 0.1 percent, avoiding the loss of moisture to the extent possible. Record the weight for use in later calculations.

4.2 Dry the sample thoroughly in the sample container by means of the selected source of heat, exercising care to avoid loss of any particles.

4.3 When a hot plate or a source of heat other than the controlled temperature oven is used, the material shall be carefully stirred with a metal rod, spoon or other suitable tool in such a way that none of the sample is lost. Particles of aggregate adhering to the tool used for stirring shall be returned to the sample.

4.4 As soon as the sample of aggregate has been dried, remove it from the source of heat and allow to cool confortable handling temperature. (NOTE 2).

NOTE 2 — A sample is dry when its weight becomes constant.

4.5 When the sample has been sufficiently cooled, weigh the sample and record the weight to the nearest 0.1 percent. (NOTE 3).

NOTE 3 — Never place hot material on a scale or balance. If the sample is too hot to handle, it is too hot to weigh accurarely.

5. Calculations

5.1 Calculate total moisture content as follows:

$$\frac{W - D}{D} \times 100 = P$$

Where:
P = moisture content of sample
W = weight of original sample, g, (Sec. 4.1)
D = weight of dried sample, g, (Sec. 4.5)

5.2 Surface moisture content is equal to the difference between the total moisture content and the absorption. Obtain the percent of absorption for the aggregate under test from the appropriate Bulletion 13 or 14. Fine Aggregate is listed in Bulletion 14 and Coarse Aggregate is listed in Bulletin 13.

5.3 After having obtained the percent of absorption from the respective Bulletin 13 or 14, subtract the percent of absorption from the total percentage of moisture contained in the sample, Section 5.1 and the difference obtained is the surface moisture of that particular aggregate. (NOTE 4).

NOTE 4 — An example of the calculations is as follows:

Wet weight of an original sample of fine aggregate	528.6 grams (W)
Weight of the same sample of fine aggregate after drying	485.3 grams (D)
Absorption of this source of fine aggregate taken from Bulletin 14	1.26

$$\frac{528.6 - 485.3}{485.3} \times 100 = 8.92\%$$ Total Moisture contained in the sample. (P)

$8.92 - 1.26 = 7.66\%$ Surface Moisture

6. Reference

ASTM C 566
PTM 625
PTM 123
PTM 504
Bulletin 13
Bulletin 14

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 504
February 1971
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

SURFACE MOISTURE IN FINE AGGREGATE

1. Scope

1.1 This method of test covers a procedure for determining, in the field, the amount of surface moisture in fine aggregate by displacement in water. The accuracy of the method depends upon accurate information on the bulk specific gravity of the material in a saturated surface-dried condition. The same procedure, with appropriate changes in the size of sample and dimensions of the container, may be applied to coarse aggregate. The method is in accordance with AASHO T142. (NOTE 1).

NOTE 1 - Either Pa. Test Method No. 123 or Pa. Test Method No. 503 is an acceptable alternate for determining the surface moisture in fine aggregate.

2. Apparatus

2.1 Balance. — A balance having a capacity of 2 kg. or more and sensitive to 0.5 g. or less.

2.2 Flask. — A suitable container or flask, preferably of glass or noncorrosive metal. The container may be a pycnometer, a volumetric flask, a graduated volumetric flask or other suitable measuring device. The volume of the container shall be from 2 to 3 times the loose volume of the sample. The container shall be so designed that it can be filled to mark, or the volume of its contents read, within 0.5 ml. or less.

3. Sample

3.1 Obtain a representative sample of the fine aggregate to be tested for surface moisture content. The sample shall weigh not less than 200 g. Larger samples will yield more accurate results. In no case, however, should the selection of a sample of a predetermined weight be attempted.

3.2 Determine to the nearest gram the weight of the sample.

4. Procedure

4.1 Determine the surface water content either by weight or by volume. In each case the test shall be made in a place where the temperature is between 65 to 85 F (18 to 29 C). The temperature of the water also, must be in this range.

4.2 Determination by Weight

Fill the container with water to the mark and determine its weight to the nearest gram; then empty the container. Put enough water back into the container to cover the sample. Place the sample in the container. Then tilt, roll, and, if necessary, shake the container to remove all the entrapped air bubbles. Fill the container with water to the original mark and weigh to the nearest gram.

Calculate the volume of water displaced by the sample as follows:

$$V = C + S - W$$

where:

V = weight of water displaced by sample, in grams
C = weight of container filled to mark with water in grams
S = weight of sample, in grams, and
W = weight of container and sample, filled to mark with water, in grams.

NOTE: For the range of temperature specified in Section 4.1, above, a volume of water expressed in cubic centimeters or milliliters is equal to the weight expressed in grams.

4.3 Determination of Volume

Measure to the nearest milliliter a volume of water sufficient to cover the sample and pour it into the container. Place the weighed sample in the container and tilt, roll, and, if necessary, shake the container to remove all the entrapped air bubbles. If a container with graduations has been used, read the combined volume of water and sample directly. If the container is a pycnometer or volumetric flask, fill the container to the mark with a volume of water measured to the nearest milliliter. This measured volume of water required to fill the container to the mark is subtracted from the volume of the container before calculating the volume of the sample in the formula below.

$$V = A - B$$

where:

V = volume of water displaced by sample, in milliliters.
A = combined volume of sample and water, in milliliters, and
B = volume of water required to cover sample, in milliliters.

5. Calculation

5.1 Calculate the percentage of surface moisture in terms of the saturated-surface-dry fine aggregate, as follows:

$$P = \frac{V - \frac{W}{G}}{W - V} \times 100$$

where:

P = surface moisture in terms of saturated-surface-dry fine aggregate in percent,
G = bulk specific gravity of the fine aggregate in a saturated-surface-dry condition, determined as prescribed in the Method of Test for Specific Gravity and Absorption of Fine Aggregate, PTM 505.
V = weight of water displaced, in grams, and
W = weight of sample, in grams.

6. References

PTM 505
AASHO T 142
ASTM C 70

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method 505
February, 1974
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE

1. Scope

1.1 This method covers the determination of bulk and apparent specific gravity and absorption (after 24 ± 4 hrs. in water) of fine aggregate. Bulk specific gravity, saturated surface-dry basis, is the value used by the Department for calculations in connection with portland - cement concrete.

2. Apparatus

2.1 Balance — A balance or scale having a capacity of 1 kg or more, sensitive to 0.1 g or less, and accurate within 0.1 percent of the test load at any point within the range of use for this test. Within any 100 g range of test load, a difference between readings shall be accurate within 0.1 g.

2.2 Volumetric Flask — A volumetric flask of 500 cm^3 capacity, a pycnometer or other suitable container into which the fine aggregate test sample can be readily introduced and in which the volume content can be reproduced within ± 0.1 $cm.^3$ The volume of the container filled to mark shall be at least 50 percent greater than the space required to accommodate the test sample. A fruit jar fitted with a pycnometer top is considered to be satisfactory for a 500 g test sample of most fine aggregates.

2.3 Mold — A metal mold in the form of a frustum of a cone 1.5 in. (38 mm) in diameter at the top, 3.5 in. (89mm) in diameter at the bottom, and 2.9 in. (74mm) in height, with the metal having a minimum thickness of 20 gage (approximately 0.9mm).

2.4 Tamper — A metal tamper weighing 12 ± ½ oz. (340 ± 15 g) and having a flat circular tamping face 1 ±1/8 in. (25 ± 3mm) in diameter.

2.5 Oven — An oven capable of maintaining a uniform temperature of 110 ± 5C (230 ± 9F).

3. Preparation of Sample

3.1 Obtain approximately 1000g of the fine aggregate from the sample in accordance with PTM 625. The selection of samples of a predetermined weight shall not be attempted. Cover with water, and permit to stand for 24 + 4 h. Decant excess water with care to avoid loss of fines, spread the sample on a flat surface exposed to a gently moving current of warm air, and stir frequently to secure uniform drying. Continue this operation until the test sample approaches a free-flowing condition. Then place a portion of the partially dried fine aggregate loosely into the mold, held firmly on a smooth non-absorbent surface with the large diameter down, lightly tamp the surface 25 times with the tamper, and lift the mold vertically. If surface moisture is still present, the fine aggregate will retain the molded shape. Continue drying with constant stirring and test at frequent intervals until the tamped fine aggregate slumps slightly upon removal of the mold. This indicates that it has reached a surface-dry condition (Note 1). If desired, mechanical aids may be employed to assist in achieving the saturated surface-dry condition.

NOTE 1 — The procedure described in Section 3., Preparation of Sample, is indicated to ensure that the first trial determination will be made with some surface water in the sample. If the fine aggregate slumps on the first trial, it has been dried past the saturated and surface-dry condition. In this case thoroughly mix a few millititers of water with the fine aggregate and permit the sample to stand in a covered container for 30 min. The process of drying and testing for the free-flowing condition shall then be resumed.

4. Procedure

4.1 Immediately introduce into the flask 500.0 g (Note 2) of the fine aggregate, prepared as described in 3.1, Preparation of Sample, and fill with water to approximately 90 percent of capacity. Roll, invert and agitate the flask to eliminate all air bubbles. Adjust its temperature to 73.4 ± 3F (23 ± 1.7C), if necessary, by immersion in circulating water and bring the water level in the flask to its calibrated capacity. Determine the total weight of the flask, sample, and water (Note 3). Record this and all other weights to the nearest 0.1 g.

NOTE 2 — An amount other than 500g. but not less than 50g. may be used provided that weight is inserted in place of the figure "500" wherever it appears in the formulas of 5.1, 6.1, 7.1 and 8.1. If the weight used is less than 500 g, limits on accuracy of weighing and measuring must be scaled down in proportion.

NOTE 3 — As an alternative, the quantity of water necessary to fill the flask may be determined volumetrically using a buret accurate to 0.15 cm.^{3} The total weight of the flask, sample, and water is then computed as follows:

$$C = 0.9976\ Va + 500 + W$$

where:

C = Weight of flask filled with sample plus water, g,
Va = Volume of water added to flask, cm^3, and
W = Weight of the flask empty, g.

4.2 Remove the fine aggregate from the flask, dry to constant weight at a temperature of 110 ± 5C (230 ± 9F), cool in air to comfortable handling temperature, weigh and record the weight to the nearest 0.1 g.

4.3 Determine the weight of the flask filled to its calibration capacity with water at 73.4 ± 3F (23 ± 1.7C).

NOTE 4 — When a volumetric flask is used, calibrate to an accuracy of 0.15 cm^3 at 20 C and calculate the weight of the flask filled with water as follows:

$$B = 0.9976\ V + W$$

where:

B = weight of flask filled with water, g,
V = volume of flask, cm^3, and
W = weight of the flask empty, g.

5. Bulk Specific Gravity

5.1 Calculate the bulk specific gravity from the following formula.

$$\text{Bulk sp gr} = \frac{A}{B + 500 - C}$$

where:

A = weight of oven-dry sample in air, g,
B = weight of flask filled with water, g, and
C = weight of flask with sample and water to calibration mark, g,

6. Bulk Specific Gravity (Saturated Surface-Dry Basis)

6.1 Calculate the bulk specific gravity on the basis of weight of saturated surface-dry aggregate from the following formula:

$$\text{Bulk sp gr (saturated surface-dry basis)} = \frac{500}{B + 500 - C}$$

where:

B = weight of flask filled with water, g
C = weight of flask with sample and water to calibration mark, g

7. Apparent Specific Gravity

7.1 Calculate the apparent specific gravity from the following formula:

$$\text{Apparent sp gr} = \frac{A}{B + A - C}$$

where:

A = weight of oven-dry sample in air, g
B = weight of flask filled with water, g, and
C = weight of flask with sample and water to calibration mark, g

8. Absorption

8.1 Calculate the percentage of absorption from the following formula:

$$\text{Absorption, Percent} = \frac{500 - A}{A} \times 100$$

where:

A = weight of oven-dry sample in air, g

9. Precision

9.1 The specific gravity and absorption values reported shall each be the average of two determinations; except that where the individual specific gravity determinations differ by more than 0.02 or the individual absorption determinations differ by more than 0.05, a third and fourth determination shall be made from the same sample, and the average of the four shall be reported.

10. Reference

AASHTO T84

End of Text PTM 505

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 506
February, 1974
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE

1. Scope

1.1 This method of test is intended for use in making determinations of bulk and apparent specific gravity, and absorption (after 24 ± 4 hrs. in water) of coarse aggregate. The bulk specific gravity is the value generally desired for calculations in connection with portland-cement concrete.

2. Apparatus

2.1 Balance — A balance having a capacity of 5 kg. or more and accurate to 1.0 g. or less.

2.2 Wire Basket — A wire basket of No. 6 or 8 mesh, approximately 8 in. in diameter and 8 in. in height.

2.3 A suitable container for immersing the wire basket in water and suitable apparatus for suspending the wire basket from center of scale pan of balance.

2.4 Oven — An oven capable of maintaining a uniform temperature of 110 ± 5 (230 ± 9F).

3. Sample

3.1 A representative sample sufficient to yield not less than the quantity required for test shall be selected by reducing the total amount in accordance with PTM 625 and then discarding all material passing a specified No. 8 or No. 4 sieve. A No. 8 sieve shall be used for testing aggregates with a nominal maximum size of ½-inch or less and a No. 4 sieve shall be used for aggregates having a nominal maximum size of 1 inch.

Nominal Maximum Size, inches	Minimum Weight of Sample, kg
½ or less	2
1	4

4. Procedure

4.1 Thoroughly wash to remove dust or other coatings from the surface of the particles and then immerse in water for a period of 24 ± 4 hours. Remove from the water and roll in a large absorbent cloth until all visible films of water are removed, although the surfaces of the particles still appear to be damp. The larger fragments may be individually wiped. Care should be taken to avoid evaporation during the operation of surface drying. Weigh the saturated surface-dry sample to the nearest 1.0 g. Make all subsequent weighings to the nearest 1.0 g.

4.2 After weighing, place the saturated surface-dry sample immediately in the wire basket and weigh in water at 73.4 ± 3F (23 ± 1.7C).

4.3 Dry the sample to constant weight at a temperature of 110 ± 5 C (230 ± 9F), cool to comfortable handling temperature and weigh.

5. Bulk Specific Gravity

5.1 Calculate the bulk specific gravity from the following formula.

$$\text{Bulk sp. gr.} = \frac{A}{B - C}$$

where:

A = weight in grams of oven-dry sample in air.
B = weight in grams of saturated surface-dry sample in air, and
C = weight in grams of saturated sample in water.

6. Bulk Specific Gravity (Saturated Surface-Dry Basis)

6.1 Calculate the bulk specific gravity on the basis of the weight of the saturated surface-dry aggregate by the following formula:

$$\text{Bulk sp. gr. (saturated surface-dry basis} = \frac{B}{B - C}$$

7. Apparent Specific Gravity

7.1 Calculate the apparent specific gravity by the following formula:

$$\text{Apparent sp. gr.} = \frac{A}{A - C}$$

8. Absorption

8.1 Calculate the percentage of absorption by the following formula

$$\text{Absorption, percent} = \frac{B - A}{A} \times 100$$

9. Report

9.1 The specific gravity and absorption values reported shall each be the average of two determinations; except that where the individual specific gravity determinations differ by more than 0.02 or the individual absorption determinations differ by more than 0.20, a third and fourth determination shall be made and the average of the four shall be reported (Note 1).

NOTE 1 — These tolerances do not apply to slag aggregates where the average of three determinations shall be reported.

10. References

AASHTO T 85
ASTM C 127

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 507
February 1972
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

BULK SPECIFIC GRAVITY (SATURATED SURFACE-DRY BASIS), ABSORPTION, AND SOLID VOLUME OF SLAG COARSE AGGREGATE

1. Scope

1.1 This method of test is intended for use in making, in the field, the determinations of bulk specific gravity (saturated surface-dry), absorption, and the solid volume of slag coarse aggregate (Note. 1).

NOTE 1. The bulk specific gravity (S.S.D.) is the value generally desired for calculating proportions of aggregates to be used in portland-cement concrete. (It should be recognized that the value obtained by this test is not a true determination because of the variation within the material. However, it is a satisfactory method). After having obtained numerous values, it is possible to arrive at an average value which is referred to as the "Bulk Specific Gravity Factor for Slag."

2. Apparatus

2.1 Balance – The balance or scale shall have a sensitivity of not less than 0.1 lbs.

2.2 Tamping Rod – Refer to PTM 609, Section 2.

2.3 Measure – Refer to PTM 609 and use a one cubic foot measure meeting the requirements specified in Section 2.3.

3. Calibration of Measure

3.1 Refer to PTM 609, Section 3.

4. Sample

4.1 Select a sample representative of the material to be tested, in the combination of sizes to be used in the concrete, and mix thoroughly. Exercise care to prevent segregation of the material and to prevent evaporation of moisture from the material during test.

5. Determination of Surface Moisture

5.1 Refer to PTM 506 and do the following:

5.1.1 Obtain a sample in accordance with Section 3.1 and discard the material passing a No. 4 sieve. Immediately weigh the resultant sample to the nearest 1.0g and record the weight. Make all subsequent weighings to the nearest 1.0g.

5.1.2 Roll the material in a large absorbent towel until all visible films of water are removed, although the surfaces of the particles still appear to be damp. The larger fragments may be individually wiped. Exercise care to prevent evaporation during operation of surface drying. Weigh the saturated surface-dry sample immediately and record the weight. After recording the weight,dry the sample to constant weight for use in Section 6.

5.1.3 Subtract the surface-dry weight obtained in 5.1.2 from the sample weight recorded in 5.1.1 and calculate the percentage of surface moisture from the following formula:

$$\frac{100(A - B)}{B} = C$$

where:

A = Original wet weight of sample (5.1.1)
B = Surface-dry weight of sample (5.1.2)
C = Percent of surface moisture

6. Absorption

6.1 After drying the sample to constant weight, (Section 5.1.2) remove from source of heat and cool to room temperature.

NOTE: Never place hot material on a scale or balance. If the sample is too hot to handle, it is too hot to weigh accurately.

6.2 Weigh the sample and calculate the percentage of absorption from the following formula:

$$\frac{100\,(B-F)}{F} = \text{Absorption, percent}$$

where:

B = Weight of sample, S.S.D. (5.1.2)
F = Weight of sample after drying (5.1.2)

7. Loose Unit Weight Determination of Surface-Dry Aggregate

7.1 Refer to PTM 609 and, using the "Shoveling Procedure" outlined in Section 7.1, determine the wet unit weight of the aggregate by multiplying the net weight of the aggregate in the measure by the factor found as described in Section 3.1. The product is the Wet Loose Unit Weight of the material (Note 2). Keep the material intact in the container where it shall remain undisturbed for use in later Solid Volume Determinations.

NOTE 2. Results with the same material should check within 1.0 percent.

7.2 Calculate the Unit Weight of Surface-Dry Aggregate from the following formula.

$$\frac{H \times 100}{D} = E$$

where:

H = Loose Unit Weight of wet aggregate
D = Percent of Surface Moisture + 100 percent
E = Loose Unit Weight of Surface-dry Aggregate

8. Determination of Weight per Solid Volume (lbs./Cu. ft.)

8.1 Compact the material retained in the container (Section 6.1), preferably by jigging, so that all of the pieces of aggregate are below the top surface of the measure. Then inundate the aggregate with water, agitating or tapping the measure (Note 3) as the water is being added, in order to remove all of the entrapped air. After all of the aggregate has been covered with water, place the container with aggregate and water on a level platform scale. Add water to the measure to the point of overflowing and carefully wipe dry any water which may have spilled onto the outer surface of the measure or the platform scale.

NOTE 3. A rubber mallet or a metal tamping rod may be used satisfactorily for tapping the measure in order to remove entrapped air while water is being added.

8.2 Calculate the Solid Volume by using the following formulas:

$$\frac{J-E}{K} = V \qquad 100\text{-}V=S \qquad \frac{E}{S} = T$$

where:

J = Loose Unit Weight of wet aggregate plus the weight of water required to fill the container.
E = Loose Unit Weight of surface-dry aggregate
K = Weight of water per cubic foot (62.4 lbs)
S = Percent of Solids
V = % volume of voids
T = Weight per Solid Volume (lbs./cu. ft.)

9. Bulk Specific Gravity of Slag Aggregate (S.S.D.)

9.1 Calculate the Bulk Specific Gravity of Slag Aggregate, (Saturated Surface-Dry Basis) from the following formula:

$$\frac{T}{K} = R$$

where:

T = Solid Volume (Lbs. per cubic foot)
K = Weight of Water per cubic foot (62.4 lbs.)
R = Bulk Specific Gravity of Slag Aggregate, Saturated Surface Dry Basis

10. References

PTM 506
PTM 509

End of text PTM 507

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 509
March 1973
3 Pages

STANDARD METHODS FOR SAMPLING PORTLAND CEMENT

1. Scope

1.1 These methods cover the taking of samples of hydraulic cement from the manufacturer's storage bins, from bulk transport units, from storage bins at concrete plants, and from bags of cement. The samples may be taken for acceptance testing, for quality assurance, or for investigational purposes.

2. Units of Measurement

2.1 Cement in bulk storage or transport shall be measured in tons. A ton weighs 2000 pounds and represents 5.32 barrels of cement.

3. Size, Number and Protection of Samples

3.1 Each individual sample shall weigh not less than 5 lb and shall be placed in moisture-proof, air-tight containers to prevent moisture absorption and aeration of the sample. If the samples are placed in cans, fill the cans completely full and seal immediately. Moisture-proof, multiple-wall paper bags may be used if they are strong enough to avoid breakage, and if they can be sealed immediately after filling in such a manner as to eliminate excess air in the sample and prevent moisture absorption and aeration of the sample.

NOTE – Cement should not be placed in direct contact with plastic containers unless the cement manufacturer has satisfied himself that the plastic will not have an adverse affect on the cement tests. Polyvinyl chloride containers have been found to affect the air-entraining potential of cement samples. The same problem might be experienced with containers made from other plastics.

3.2 Number the containers consecutively in the order in which the samples were taken and show clearly on Form TR-447, Sample Identification, the manufacturer, plant location, bin number, and the size of the lot of cement represented by the set of samples. In addition, samples obtained from a concrete plant shall also show the concrete plant location, name of the concrete producer, and acceptance card or affidavit number.

4. Sampling

4.1 From Bulk Storage at Cement Plant or Shipping Terminal

Sample the cement as it flows from the discharge openings at such intervals that one 5-lb sample will be obtained for each 100 tons of cement. The procedure for determining the rate of sampling cement is explained in the Appendix to this PTM.

4.2 From Bulk Shipment of Car or Truck

Take three samples weighing at least 5 lb each from three well-distributed points. Where shipment consists of several cars or trucks loaded from the same storage bin on the same day, take 5-lb samples at the rate of at least one sample per 100 tons.

4.3 From Bulk Storage at a Concrete Plant

Take three samples weighing at least 5 lb each from three well-distributed points in the bin. When the samples are taken from the discharge of the bin, they shall be taken to represent the cement flowing into three separate batches of concrete.

4.4 From Packaged Cement

4.4.1 For shipments of 25 bags or less, take one 10-lb sample from one bag.

4.4.2 For shipments of more than 25 bags, take one 5-lb sample from one bag for each 25 bags.

5. Shipment

5.1 When transportation is not provided by the Department, the individual samples shall be placed in a container which shall then be secured with a Department seal.

Reference:

ASTM C183
AASHO T127

APPENDIX

DETERMINATION OF SAMPLING RATE FOR CEMENT IN BULK STORAGE AT CEMENT PLANT OR SHIPPING TERMINAL

Withdraw cement from the discharge openings in a steady stream until sampling is completed by either or the following two methods: (1) Place markers on top of the cement in the bin or silo. Sampling at any discharge opening is completed when a marker passes through the opening. If a limited amount of cement (50 to 100 tons) is withdrawn before placing indicators in order to develop a conical depression in the top surface of the cement, the quantity so withdrawn shall be sampled and considered as part of a test sample. (2) The quantity of cement in tons to be withdrawn from one discharge opening may be estimated as $.00032d^3$, where d is the depth in feet of cement above the discharge opening. If a high circular silo is being sampled, all samples may be taken from one opening. If the quantity of the cement in the bin exceeds 1200 tons when low rectangular bins are being sampled, the number of discharge openings employed in the sampling shall be such that for no opening shall the number of samples represent more than one half the contents of the bin or more than 2000 tons.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 513
June 13, 1974
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

TOTAL MOISTURE IN ANTI-SKID MATERIALS

1. Scope

1.1 This method of test covers the procedure for determing, in the field, the total amount of moisture in anti-skid materials.

2. Apparatus

2.1 Balance. The balance or scale shall have a sensitivity of not less than 0.1 gram.
2.2 Hot Plate. Either gas or electric of sufficient heating capacity.
2.3 Oven. The oven shall be capable of maintaining a uniform temperature of 110 ± 5 C (230 ± 9 F).
2.4 A small metal pan or dish, such as a pie pan or biscuit pan for use in drying the test sample.

3. Samples

3.1 Obtain all samples in accordance with PTM 607.
3.2 Reduce the sample in accordance with PTM 625 until the approximate minimum weight of the test portion is as follows:

Anti-Skid Material, Type	Approximate Minimum Weight in Grams (Note 1)
I	1500
II	1500
III	500
IV	1500

NOTE 1: In no case, however, should the selection of a sample of a predetermined weight be attempted.

4. Procedure

4.1 The sample selected for test shall be weighed, and the weight, to be used in later calculations, recorded to the nearest 0.1 gram.
4.2 The pan containing the sample for test shall be placed in an oven or on a hot plate as specified in Section 2.
4.3 When a hot plate is used, the material shall be carefully stirred with a metal rod, spoon or other suitable tool in such a way that none of the sample is lost. Particles of material adhering to the tool used for stirring shall be returned to the test sample.
4.4 As soon as the test sample has been dried, remove it from the source of heat and allow to cool to comfortable handling temperature (NOTE 2).

NOTE 2: A sample is dry when its weight becomes constant.

4.5 After cooling, weigh the test sample and record the weight to the nearest 0.1 gram (NOTE 3).

NOTE 3: Never place hot material on a scale or balance. If the sample is too hot to handle, it is too hot to weigh accurately.

5. Calculations

5.1 Subtract the dry weight of the test sample from the original weight or wet weight of the test sample. Record to the nearest 0.1 gram the difference, which is the total amount of moisture contained in the test sample.

5.2 Divide the amount of moisture contained in the test sample, Section 5.1, by the dry weight, Section 4.1, and record the total percent of moisture contained in the test sample (NOTE 4).

NOTE 4: An example of the calculations is as follows:

Wet weight of an original sample of Anti-Skid Material, Type III	528.6 grams
Weight of the same sample of Anti-Skid Material after drying	485.3 grams

$$\frac{528.6 - 485.3}{485.3} \times 100 = 8.92\% \text{ Total Moisture contained in the sample.}$$

6. Reference

PTM 607
PTM 625

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 515
August 1976
2 Pages

Bureau of Materials, Testing and Research

Method of Test for
Bleeding and Expansion of Grouting Material

1. SCOPE

1.1 This method of test covers the procedure for determining the volume percent of bleeding and expansion of grouting material.

2. APPARATUS

2.1 Graduated Cylinder - A glass cylinder of 500-ML capacity to hold grout during test.

2.2 Graduated Cylinder - A glass cylinder of 100-ML capacity for collecting and measuring the quantity of water withdrawn.

2.3 Pipet or similar instrument, for drawing off free water from the surface of the test specimen.

2.4 Large spoon or similar instrument for filling the 500-ML cylinder with grout.

2.5 Glass rod - A glass rod about two feet long for dispelling any voids which may be in the test specimen.

3. TEST SPECIMEN

3.1 For grout made in the laboratory, prepare the grout using a large paddle-type mixer with a metal bowl (similar to that made by Hobart Company). The ingredients of the grout shall be proportioned according to manufacturers directions. In the case of slab-jacking grout, ingredients shall be proportioned as described in Section 681 of form 408.

3.1.1 Start the paddle of the mixer and slowly add the ingredients. Prepare about one tenth of a cubic foot (3000 cu cm) of grout. Mix the ingredients together for two minutes so that they are well blended.

3.2 For grout made in the field, sample the grout as described in Standard Method of Sampling Fresh Concrete (ASTM C-172 or AASHO T-141) making any adjustments that are needed in substituting grout for concrete in the Method.

3.3 Using a spoon or similar instrument, fill the 500-ML graduate approximately half full of grout, rodding if necessary.

4. PROCEDURE

4.1 Using the gradations on the side of the cylinder, read the height of the column of grout to the nearest milliliter. This is the original reading used for both expansion and bleeding determinations.

4.2 Bleeding Determination: After taking the original reading, draw off (with a pipet or similar instrument) the water that has accumulated on the surface of the test specimen; at 10-min. intervals during the first 40 min. and at 30-min. intervals thereafter until cessation of bleeding. After each withdrawal, transfer the water to a 100-ML graduate. Record the accumulated quantity of water after each transfer.

4.3 Expansion Determination: Simultaneously with the withdrawal of bleeding water, record the height of the column of grout at 10-min. intervals during the first 40 min. and at 30-min. intervals thereafter until cessation of expansion. Cessation of expansion will have occurred when three successive readings are equal.

5. CALCULATIONS

5.1 To determine volume percent of bleeding water, use the following equation:

$$\frac{(100)\ Vw}{Vo} = B$$

Where:

Vw = Total volume of "bleeding" water, in milliters, measured during the selected time interval.
Vo = Original reading of the 500-ML graduate.
B = Bleeding (%).

5.2 To determine the volume percent expansion, first subtract the final volume of grout from the original volume of grout. Then divide the difference by the original volume and multiply by 100.

$$\frac{(100)\ Vo - Vf}{Vo} = E$$

Where:

Vo = Original volume of grout in millileters.
Vf = Final volume of grout in millileters.
E = Expansion or shrinkage (%).

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 600
August 1968
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

SLUMP OF PORTLAND CEMENT CONCRETE

1. Scope

1.1 This method of test covers the procedure to be used for determining slump of concrete, both in the laboratory and in the field. This method is in accordance with the AASHO T 119 procedure but includes additional detailed descriptions.

NOTE 1--This test is not considered applicable to nonplastic and noncohesive concrete, nor when there is a considerable amount of coarse aggregate over 2 in. in size in concrete.

2. Apparatus

2.1 Mold--The test specimen shall be formed in a mold having the shape of a frustum of a right circular cone with inside diameters at the top and bottom of 4 ± 1/16 inch and 8 ± 1/16 inch, respectively, and a height of 12 ± 1/16 inch (Fig. 1). The mold shall be made of metal not thinner than No. 16 gage and of a type not readily attacked by cement paste. The mold shall be provided with foot pieces and handles as shown in Figure 1 (Note 2).

NOTE 2--The foot pieces and handles should be attached and constructed so that no bending or movement occurs after repeated usage. The cone must also be kept clean with particular care being taken to retain a smooth surface on the inside.

2.2 Tamping Rod--The tamping rod shall be a round, straight steel rod 5/8 in. in diameter and approximately 24 in. length, having one end rounded to a hemispherical tip the diameter of which is 5/8 in. (Note 3).

NOTE 3--A rod with a square end or reinforcing bar shall not be used since bars of this type push large aggregates toward the bottom causing an error in test results. A scoop with a rounded bottom is suggested for putting concrete into the slump cone.

3. Sample

3.1 The sample of concrete from which test specimens are made shall be representative of the entire batch. It shall be obtained in accordance with the Method of Sampling Fresh Concrete PTM 601 (Note 4).

NOTE 4--It is best to collect portions of the sample in a wheelbarrow, mix them well and fill the slump cone from the wheelbarrow. It is difficult to fill the cone properly from a small container so a bucket should not be used. Concrete that has been vibrated shall not be used when making the slump test.

4. Procedure

4.1 Dampen the mold and place it on a flat, moist, nonabsorbent (rigid) surface. It shall be held firmly in place during filling. From the sample of concrete obtained in accordance with Section 3, immediately fill the mold in three layers, each approximately one third the volume of the mold (Note 5).

NOTE 5--One third of the volume of the slump mold fills it to a depth of 2 5/8 in.; two thirds of the volume fills it to a depth of 6 1/8 in. To make sure each layer of concrete is rodded to the proper depth, rings may be filed on the surface of the rod at distances of 12, 10 and 6 1/2 in. from the rounded point.

4.2 Rod each layer with 25 strokes of the tamping rod. Uniformly distribute the strokes over the cross-section of each layer. For the bottom layer this will necessitate inclining the rod slightly and making approximately half of the strokes near the perimeter, and then progressing with vertical strokes spirally toward the center. Rod the bottom layer throughout its depth. Rod the second layer and the top layer each throughout its depth, so that the strokes just penetrate into the underlying layer.

4.3 In filling and rodding the top layer, heap the concrete above the mold before rodding is started. If the rodding operation results in subsidence of the concrete below the top edge of the mold, add additional concrete to keep an excess of concrete above the top of the mold at all times. After the top layer has been rodded, strike off the surface of the concrete by means of a screeding and rolling motion of the tamping rod. Remove the mold immediately from the concrete by raising it carefully in a vertical direction (Note 6).

NOTE 6--**The operation of raising the mold shall be performed in approximately 5 sec. by a steady upward lift with no lateral or torsional motion being imparted to the concrete. The entire operation from the start of the filling through removal of the mold shall be carried out without interruption and shall be completed within an elapsed time of 2 min.**

4.4 Immediately measure the slump by setting the cone large end down alongside the slumped concrete. The indicated slump is the measurement from the bottom of the rod or straightedge to a point on the surface of the slumped concrete. This point must be directly over a point that was on the axis, or centerline of the cone while it was being filled. The slump is recorded to the nearest 1/4 inch. If a decided falling away or shearing off of concrete from one side or portion of the mass occurs (Note 7), disregard the test and make a new test on another portion of the sample.

NOTE 7--**If two consecutive tests on a sample of concrete show a falling away or shearing off of a portion of the concrete from the mass of the specimen, the concrete probably lacks necessary plasticity and cohesiveness for the slump test to be applicable.**

5. Reference

AASHO Designation T 119-
ASTM Designation C 143-

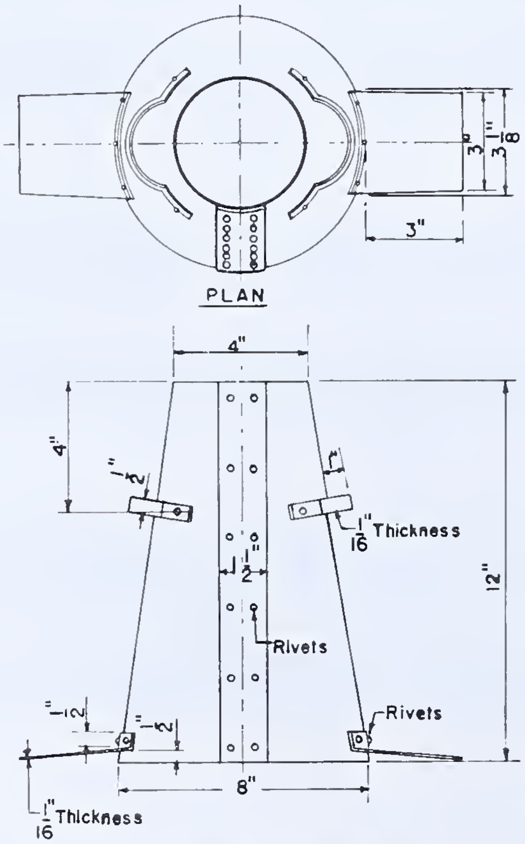

Fig. 1.—Mold for Slump Test.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 601
June 1973
2 Pages

Bureau of Materials, Testing & Research

METHOD OF SAMPLING FRESH CONCRETE

1. Scope

1.1 This method covers the procedure for obtaining samples of fresh concrete from stationary and paving mixers, and from truck mixers, agitators, or dump trucks, and is a modification of AASHO T 141

2. Size of Sample

2.1 The sample shall consist of not less than 1 cu. ft. when it is to be used for strength tests. Smaller samples may be permitted for routine air content and slump tests.

3. Procedure for Sampling

3.1 The procedures used in sampling shall include the use of every precaution that will assist in obtaining samples that will be representative of the true nature and condition of the concrete sampled, as follows:

3.1.1 Sampling from Stationary Mixers, Except Paving Mixers. The sample shall be obtained after the material is discharged into the hauling equipment. The sample for testing shall be taken by whichever of the procedures described in Paragraph 3.1.2 or 3.1.3 is most applicable under the given conditions. These requirements apply to both tilting and nontilting mixers.

3.1.2 Sampling from Paving Mixers. The contents of the paving mixer shall be discharged, and the sample shall be collected from at least five different portions of the pile.

3.1.3 Sampling from Revolving Drum Truck Mixers or Agitators. The sample shall be taken from the first one third of the batch and subsequent portions if required, except that samples shall not be taken at the beginning or end of discharge. Sampling shall be done by repeatedly passing a receptacle through the entire discharge stream, or by diverting the stream completely so that it discharges into a container. The rate of discharge of the batch shall be regulated by the rate of revolution of the drum, and not by the size of the gate opening. The slump and air content of the concrete shall be determined before one-third of the batch has been placed.

3.1.4 Sampling from mobile concrete proportioning and mixing trucks. Take the sample after not less than 2 cubic feet of concrete have been discharged and before the last 2 cubic feet are discharged. Obtain the sample by repeatedly passing a suitable container through the entire discharge stream or by diverting the stream so that the entire stream discharges into a container. Determine the slump and air content before 1 cubic yard of concrete has been placed. Subsequent samples for determining the uniformity of mixing and for other tests shall be taken at random intervals of time in accordance with PTM 1.

3.1.5 Sampling from Open-Top Truck Mixers, Agitators, Dump Trucks, or Other Types of Open-Top Containers. Samples shall be taken by whichever of the procedure described in Paragraphs 3.1.1, 3.1.2 or 3.1.3 is most applicable under the given conditions.

4. Remixing Sample

4.1 The sample shall be transported to the place where test specimens are to be molded or where the test is to be made, and shall be remixed with a shovel to ensure uniformity. The sample shall be protected from sunlight and wind during the period between taking and using, which shall not exceed 15 min.

5. Reference:

AASHO T 141
ASTM C 172
ASTM C 685

Commonwealth of Pennsylvania
Department of

Pa. Test Method No. 602
August 1968
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE CHACE INDICATOR

1. Scope

1.1 This method of test covers the determination of the air content of fresh concrete by displacing the air with alcohol and observing the change in level of the liquid in the tube. The apparatus is light and small, and the test procedure requires only a few minutes.

1.2 This method has been found satisfactory for determining the approximate air content of freshly mixed concrete. It should not however be considered suitable for replacing PTM 613 (gravimetric), PTM 615 (pressure), or PTM 612 (volumetric), and in no case should the value obtained through the use of this method be accepted as determining the compliance of the air content of concrete with the requirements of specifications. The method is most useful for determining whether the concrete has a low, medium, or high air content, and whether the air content is reasonably constant from batch to batch of concrete. This method is in accordance with AASHO T-199

2. Apparatus

2.1 Indicator - The indicator consists of 3 pieces: a glass tube about 3 in. long and 1 inch in diameter with a stem 3 inches long and ¼ inch in diameter at one end resembling a filter tube for Gooch crucibles, a rubber stopper to fit the larger end of the glass tube, and a metal cup mounted on the smaller end of the stopper. The stem of the glass tube is scribed with 11 lines, each pair indicating a volume of 0.08 ml. A reference line is also scribed on the large portion of the tube. The brass cup is ¾ in. in inside diameter, ½ in. in depth, and contains a volume of 3.6 ml. When the stopper and cup are inserted into the glass tube the volume of the latter and stem is about 27 ml.

2.2 Alcohol - Denatured or isopropyl alcohol.

2.3 Dropper - A medicine dropper having a tip small enough to enter the graduated stem of the indicator.

3. Procedure

3.1 Fill the brass cup with cement mortar from the concrete to be tested, excluding particles of sand which would be retained on a No. 10 (2mm) sieve. A narrow knife blade is most suitable to pick up the mortar. Rod the mortar in the cup using a thin stiff wire and strike off the mortar flush with the top of the cup. Clean the sides of the cup and stopper of mortar if necessary. Close the smaller end of the indicator with a finger and fill the tube with alcohol to the reference line.

Insert the stopper into the tube, invert the indicator, and bring the level of the alcohol to the upper mark on the stem by pushing the stopper in further or by adding alcohol with the dropper. Be certain that no air bubbles are in the stem of the indicator.

Close the opening in the stem with a finger and gently roll the indicator from a vertical to a horizontal position while tapping the side of the indicator with a finger of the other hand. Care shall be taken not to change the setting of the stopper. Continue the rolling and tapping until all of the mortar is dispersed in the alcohol and no more bubbles of air appear. With the indicator held in a vertical position, remove the finger from the end of the stem and read the level of the alcohol in the stem to the nearest half graduation.

4. Computation of Air Content

4.1 If the concrete contains 15 cu. ft. of mortar per cu. yd., the change in the level of alcohol as measured by the graduations on the stem will equal the air content of the concrete. For concretes with different amounts of mortar per cubic yard, this change shall be multiplied by the values in the table of Section 6.

5. Limitations

5.1 Due to the small amount of mortar tested, the Chace indicator can not determine the air content of concrete as accurately as is obtained with the other methods mentioned in Section 1.2. However if three or more determinations are made with the Chace indicator, the average value of these determinations can be expected to furnish a suitable indication of the relative amount of beneficially entrained air in the concrete.

6. Conversion Table

6.1 For the following mortar contents per cu. yd. multiply the stem readings by the following constant:

Mortar Content cu.ft./yd.	Factor	Mortar Content cu.ft./yd.	Factor	Mortar Content cu.ft./yd.	Factor
10.0	0.67	13.5	0.90	17.0	1.13
10.5	0.70	14.0	0.93	17.5	1.16
11.0	0.73	14.5	0.96	18.0	1.20
11.5	0.76	15.0	1.00	18.5	1.23
12.0	0.80	15.5	1.04	19.0	1.26
12.5	0.83	16.0	1.07	19.5	1.30
13.0	0.86	16.5	1.10	20.0	1.33

Reference

AASHO T 199-

Commonwealth of Pennsylvania
Department of Transportation

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August 1968
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

FLEXURAL STRENGTH OF CONCRETE (USING SIMPLE BEAM WITH THIRD-POINT LOADING)

1. Scope

1.1 This method of test covers the procedure for determining the flexural strength of concrete by the use of a simple beam with third-point loading, and is a modification of AASHO T 97.

NOTE 1. For methods of molding concrete specimens see the Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field (PTM 611).

2. Apparatus

2.1 The testing machine shall conform to the requirements of Sections 15, 16, and 17 of Methods of Verification of Testing Machines (AASHO Designation: T 67). The third-point loading method shall be used in making flexure tests of concrete employing bearing blocks which will insure that forces applied to the beam will be vertical only and applied without eccentricity. A diagram of an apparatus which accomplishes this purpose is shown in Fig. 1.

NOTE 2. Apparatus for making flexure tests of concrete should be designed to incorporate the following principles:

(1) The apparatus shall be capable of maintaining the span length and distances between load-applying blocks and support blocks constant within ± 0.05 in.

(2) The load should be applied normal to the loaded surface of the beam and in such a manner as to avoid eccentricity of loading.

(3) The direction of the reactions should be parallel to the direction of the applied load at all times during the test.

(4) The load should be applied as a uniform rate and in such a manner as to avoid shock.

(5) The ratio of distance between point of load application and nearest reaction, to the depth of the beam should be not less than one.

(6) The load-applying and support blocks should be not more than 2 1/2 in. high, measured from center or axis of pivot, and shall extend across the full width of specimen. The case-hardened bearing surfaces in contact with the specimen shall be a portion of a cylinder, the axis of which is the axis of the rod or will pass through the center of the ball upon which they are pivoted.

(7) The load-applying and support blocks shall be maintained in a vertical position by means of spring-loaded screws holding them in contact with the pivot rod or ball.

(8) The uppermost bearing plate and center-point ball in Fig. 1 may be omitted when a spherically seated bearing block is used provided one rod and one ball are used as pivots for the load-applying blocks.

3. Test Specimen

3.1 The test specimen shall have a span as nearly as practicable three times its depth as tested. The sides of the specimen shall be at right angles with the top and bottom.

4. Procedure

4.1 The test specimen shall be placed in the testing machine so that the 8 in. dimension is in a vertical position . The load-applying blocks shall be brought in contact with the surface of the specimen at the third points between the supports.

4.2 The load may be applied rapidly up to approximately 50 per cent of the breaking load, after which it shall be applied at such a rate that the increase in extreme fiber stress does not exceed 150 psi. per min.

5. Measurement of Specimens After Test

5.1 Measurements to the nearest 0.1 in. shall be to determine the average width and average depth of the specimen at the section of failure.

6. Calculations

6.1 If the fracture occurs within the middle third of the span length, the modulas of rupture shall be calculated as follows:

$$R = \frac{P1}{bd^2}$$

where
R = modulus of rupture in pounds per square inch
P = maximum applied load indicated by the testing machine in pounds
1 = span length in inches
b = average width of specimen in inches, and
d = average depth of specimen in inches.

NOTE: Weight of the beam is not included in the above calculation.

6.2 If the fracture occurs outside of the middle third of the span length by not more than 5 per cent of the span length, the modulus of rupture shall be calculated as follows:

$$R = \frac{3Pa}{bd^2}$$

where:
a = distance between line of fracture and the nearest support measured along the center line of the bottom surface of the beam, in inches.

6.3 If the fracture occurs outside of the middle third of the span length by more than 5 per cent of the length the results of the test shall be discarded.

7. Report

The report shall include the following:

7.1 (1) Identification number
7.2 (2) Average width to the nearest 0.1 in.
7.3 (3) Average depth to the nearest 0.1 in.
7.4 (4) Span length in inches
7.5 (5) Maximum applied load in pounds
7.6 (6) Modulus of rupture calculated to nearest 5 psi.
7.7 (7) Curing history and apparent moisture condition of the specimen at time of test.*
7.8 (8) If specimen was capped, ground, or if leather shims were used.*
7.9 (9) Defects in specimen, and *
7.10 (10) Age of specimen. *

*This information is reported only if requested, or if unusual occurrence is discovered.

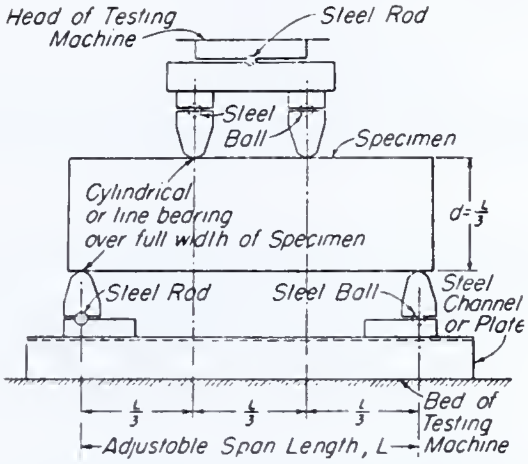

FIG. 1.—Diagrammatic View of Apparatus for Flexure Test of Concrete by Third-Point Loading Method.

8. References

AASHO T 97-
ASTM C-78-

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 604
October, 1975
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

COMPRESSIVE STRENGTH OF MOLDED CONCRETE CYLINDERS

1. Scope

1.1 This method of test covers the procedure for compression tests of molded concrete cylinders, and is a modification of AASHO T 22). A compressive strength test of concrete shall consist of two or more specimens of the same age prepared from the same sample of concrete. Specimen results which deviate from each other by approximately 1000 psi or more should be considered invalid.

2. Apparatus

2.1 The testing machine may be of any type of sufficient capacity which will provide the rate of loading prescribed in Section 4.2. It shall conform to the requirements of Section 15, 16, and 17 of the Standard Methods of Verification of Testing Machines (AASHO Designation T 67). The testing machine shall be equipped with two steel bearing blocks with hardened faces (Note 1) one of which is a spherically seated block that will bear on the upper surface of the specimen, and the other a plain rigid block on which the specimen will rest. There shall be sufficient vertical clearance between the testing heads and lateral clearance between the components of the frame to permit insertion of circular proving rings of appropriate capacity and the necessary bearing blocks so that the open face of the ring will be approximately parallel with the front of the machine. The bearing faces shall not depart from a plane by more than 0.001 in. in any 6 in. The maximum diameter of the bearing face of the suspended spherically seated block shall not exceed 10 inches. The center of the sphere shall coincide with the center of the bearing face. If the radius of the sphere is smaller than the radius of the bearing face, the portion of the bearing face extending beyond the sphere shall have a thickness not less than the difference in radii. The diameter of the sphere shall not be greater than 10 inches. The bearing faces shall be at least as large and preferably slightly larger than the surface of the specimen to which the load is applied. When the diameter of the bearing surface exceeds the diameter of the specimen by ½ in. or more, concentric circles shall be inscribed to facilitate proper centering. The movable portion of this block shall be held closely in the spherical seat, but the design shall be such that the bearing face can be rotated freely and tilted through small angles in any direction.

NOTE 1--It is desirable that the bearing faces of blocks used for compression testing of concrete have a Rockwell hardness of not less than C 60.

2.2 Each dial on (hydraulically operated) compression machines used in concrete strength tests shall be provided with a graduated scale which is at least 25 in. in length (corresponds to the usable arc of 10 in. diameter circle) and divided into not less than 400 equal parts. The scale shall be provided with a graduation line equal to zero and so numbered. The dial pointer shall be sufficient length to reach the graduation marks and the width of the leading end shall be not greater than the clear distance between the least graduations. Each dial shall be equipped with zero adjustment mechanism that can be operated from outside the dial case, and a maximum load indicator.

3. Test Specimens

3.1 Compression tests of moist cured specimens shall be made as soon as practicable after removal from the curing room. The ends of compression test specimens that are not plane within 0.002 in. shall be capped with Carbo-Vitrobond or other approved capping material. Test specimens, during their removal from the moist room and testing shall be kept moist by a wet burlap or blanket covering. They shall be tested in a moist condition. The diameter of the test specimen shall be determined to the nearest 0.01 in. by averaging two diameters measured at right angles to each other at about midheight of the specimen. This average diameter shall be used for calculating the cross-sectional area. The length of the specimen including caps shall be measured to the nearest 0.1 in.

4. Procedure

4.1 Placing the Specimen. The plain (lower) bearing block shall be placed, with its hardened face up, on the table or platen of the testing machine directly under the spherically seated (upper) bearing block. The bearing faces of the upper and lower bearing blocks and of the test specimen shall be wiped clean and the test specimen placed on the lower bearing block. The axis of the specimen shall be carefully aligned with the center of thrust of the spherically seated block. As the spherically seated block is brought to bear on the specimen its movable portion shall be rotated gently by hand so that uniform seating is obtained.

4.2 Rate of Loading. The load shall be applied continuously and without shock. In testing machines of the screw type the moving head shall travel at a rate of about 0.05 in. per min. when the machine is running idle. In hydraulically operated machines the load shall be applied at a constant rate within the range of 20 to 50 psi. per sec. During the application of the first half of the maximum load a higher rate of loading is permitted. No adjustment shall be made in the controls of the testing machine while a specimen is yielding rapidly immediately before failure.

4.3 The load shall be increased until the specimen fails and the maximum load carried by the specimen during the test shall be recorded. The type of failure and the appearance of the concrete shall be noted.

5. Calculation

5.1 The compressive strength of the specimen shall be calculated by dividing the maximum load carried by the average cross-sectional area determined as described in Section 3, and shall be expressed to the nearest 10 psi.

6. Report

6.1 The report shall include the following:

Identification number
Diameter (and length, if not standard), in inches
Cross-sectional area, in square inches
Maximum load, in pounds
Compressive strength calculated to the nearest 10 psi.
Type of fracture, if other than the usual cone.*
Defects in either specimen or caps
Age of specimen
Area or Compressive Strength
* This information is reported only if requested, or if an unusual occurrence is discovered.

7. Reference

AASHO T 22-
ASTM C 39-

Commonwealth of Pennsylvania
Department of Transportation

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3 Pages

Bureau of Materials, Testing & Research

Method of Test for

FLEXURAL STRENGTH OF CONCRETE
(Using Simple Beam With Center-Point Loading)

1. Scope

1.1 This method of test covers the procedure for determining the flexural strength of concrete by the use of a simple beam with center-point loading, and is a modification of AASHO T 177. A flexural strength test of concrete shall consist of two or more specimens of the same age prepared from the same sample of concrete. Specimen results which deviate from each other by approximately 150 psi or more should be considered invalid.

NOTE 1. For methods of molding concrete specimens, see the Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field PTM 611-

2. Apparatus

2.1 The center-point loading method shall be used. The testing machine shall conform to the requirements of Sections 15, 16, and 17 of the Methods of Verification of Testing Machines (AASHO Designation: 767). The apparatus shall incorporate the following requirements:

2.1.1 The load shall be applied at the center point of the span, normal to the loaded surface of the beam, employing bearing blocks designed to insure that forces applied to the beam will be vertical only and applied without eccentricity.

2.1.2 The direction of the reactions shall be parallel to the direction of the applied load at all times during the test.

2.1.3 The load shall be applied at a uniform rate and in such a manner as to avoid shock.

2.1.4 The edges of the load-applying block and of the supports shall not depart from a plane by more than 0.002 in.

NOTE 2. A diagram of a suitable apparatus is shown in Fig. 1.

3. Test Specimen

3.1 The test specimen shall have a span as nearly as practicable three times its depth as tested. The test specimen shall be kept wet until time of test.

NOTE 3. The nominal size of specimens shall be 6" x 8" x 22". The specimens shall be tested with the 8 " dimension in a vertical position.

4. Procedure

4.1 The test specimen shall be centered on the supporting bearing blocks. The load-applying block shall be brought in contact with the upper surface at the center line between the supports.

NOTE 4. When using the Rainhart flexural testing apparatus, the load is applied to the bottom instead of the top. See Appendix for operation of Rainhart Flexural Testing Apparatus.

4.2 The load may be applied rapidly up to approximately 50 percent of the breaking load, after which it shall be applied at such a rate that the increase in extreme fiber stress does not exceed 150 psi per min. Screw power machines, with the moving head operating at 0.05 in. per min., when the machine is running idle, may be used.

5. Measurement of Specimens

5.1 Measurements within an accuracy of at least 0.05 in. shall be made to determine the average width and average depth of the specimen at the section of failure.

6. Calculation

6.1 The modulus of rupture shall be calculated as follows:

$$R = \frac{3PL}{2bd^2}$$

where:

R = modulus of rupture in pounds per square inch,
P = maximum applied load indicated by the testing machine in pounds,
L = span length in inches, (18")
b = average width of specimen in inches, and
d = average depth of specimen in inches.

NOTE 5. Weight of the beam is not included in the above calculation.

7. Report

7.1 The report shall include the following:

7.1.1 Identification number,
7.1.2 Average width,
7.1.3 Average depth,
7.1.4 Span length in inches
7.1.5 Maximum applied load in pounds,
7.1.6 Modulus of rupture calculated to the nearest 5psi,
7.1.7 Defects in specimen, and *
7.1.8 Age of specimen.
7.1.9 Average Flexural Strength

*Omitted from our report unless requested.

8. Reference

AASHO T177
ASTM C 293

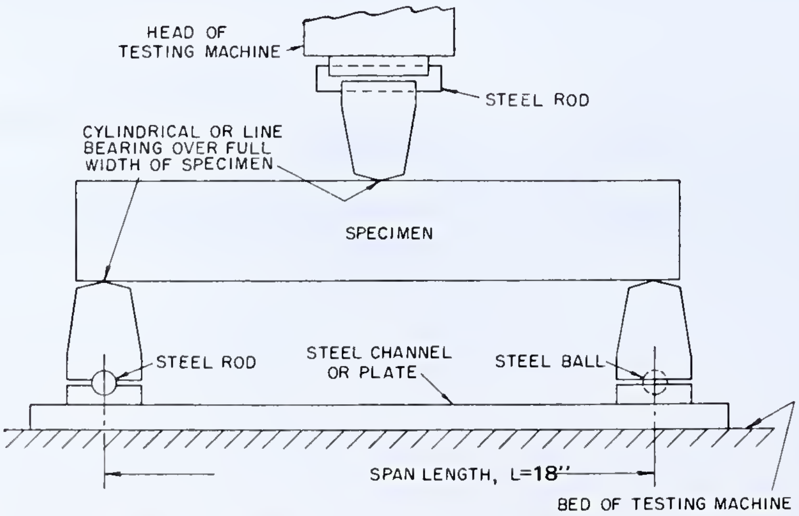


FIG. 1.—*Diagrammatic View of Apparatus for Flexure Test of Concrete by Center-Point Loading Method.*

APPENDIX

METHOD OF OPERATION FOR RAINHART FLEXURAL TESTING APPARATUS

a. BEFORE FIRST TEST EACH DAY - Open recorder-door, fully wind the chart-drive and raise pen by lifter-arm. If needed, put one drop of recorder ink only in pen-point. Clamp a No. 12218 Recording Chart on chart-hub. Lower pen by lifter-arm. If pen does not record, moisten pen-point with saliva until ink flows freely. Tap the pen-arm; adjust micrometer screw at top of pen-arm so that pen-point registers exactly on the chart zero line; repeat until the pen-point zeros consistently.

b. POSITION AND CLAMP TEST BEAM - Insert beam from right side of apparatus with the surface to be loaded underneath; using the catcher-arm as a rest while adjusting grips, etc. Center the test section in relation to the four corner posts and have at least two inches of beam projecting beyond the left cross-head. Moderately tighten four post hand-knobs so that cross-heads are approximately level (adjusts automatically for any minor beam twists).

c. POSITION AND CLAMP RECORDING CHART - Record desired pre-loading data on a No. 12218 Recording Chart. Open recorder-door and raise pen by lifter-arm. Place chart face up on chart hub and with left edge under pointed hold-down bracket. Lower pen by lifter-arm. Position chart so that pen-point is about one-half minute division to left of where the paced loading is to start and clamp in this position. Close and latch the recorder-door.

d. LOAD TO FAILURE AND REMOVE BEAM SECTIONS - Use the fast, double-action, lever pump at right for rapid beam contact and initial loading. Shift to vernier, double-action, rotary pump at left for all other loading. Whenever a stoppage point is reached, quickly reverse direction of handwheel rotation (NEVER FORCE the handwheel). So rotate the handwheel that the pen records within the chart open spiral, until the beam fails. Open control-valve until loading-head bottoms and then tighten securely. Loosen four post hand-knobs and remove beam sections. Using a damp rag, clean the top of the loading-head and wipe outward from the cylinder rim.

e. CALCULATE AND RECORD THE TEST RESULTS - Open recorder-door and raise pen by lifter-arm. Unclamp and remove chart. Lower pen by lifter-arm. Close and latch recorder-door.
Measure to the nearest 1/10th inch the average width and the average depth of the specimen at the section of failure. Record these measurements on the chart. Observe and record on chart the maximum load graphed on the chart. Unless otherwise specified, select applicable Factor from table affixed to chart box and record it on chart. Multiply the maximum recorded load in pounds by this Factor and record the resulting Flexural Strength psi on the chart. Record other significant test data on chart; sign in space after "Tested By" and properly file the chart.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 606
August 1968
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

OBTAINING AND TESTING DRILLED CORES OF CONCRETE

1. Scope

1.1 This method covers the procedures for obtaining, preparing, and testing (a) cores drilled from concrete for length or for compressive strength determinations and is in accordance with AASHO T 24-

2. Apparatus

2.1 Core drill, for obtaining cylindrical core specimens. For specimens to be removed by drilling downward perpendicular to a horizontal surface a shot drill may be satisfactory; for specimens taken by drilling in other directions or when the test specimen diameter is to be accurately determined for more precise calculation of compressive strength, a diamond drill shall be used.

3. Sampling

3.1 General. Do not take samples of hardened concrete for use in the preparation of strength test specimens until the concrete has become hard enough to permit sample removal without disturbing the bond between the mortar and the coarse aggregate. In general, the concrete shall be 14 days old before the specimens are removed. When preparing strength-test specimens from samples of hardened concrete, do not use samples that show abnormal defects or samples that have been damaged in the process of removal.

3.2 Core Drilling. A core specimen taken perpendicular to a horizontal surface shall be located, when possible, so that its axis is perpendicular to the bed of the concrete as originally placed. A specimen taken perpendicular to a vertical surface, or perpendicular to a surface with a batter, shall be taken from near the middle of a unit of deposit when possible.

4. Length of Drilled Core Specimens

4.1 Length of Specimens. A core specimen for the determination of length shall have a diameter of at least 4 in.

4.2 Procedure for Length Determination. Measure the lengths of cores in accordance with the provisions of the Method of Measuring Length of Drilled Concrete Cores (PTM 614-).

5. Compressive Strength

5.1 Test Specimens. The diameters of core specimens for the determination of compressive strength should be at least 3 times the maximum nominal size of the coarse aggregate used in the concrete, and must be at least twice the maximum nominal size of the coarse aggregate. The length of the specimen, when capped, shall be as nearly as practicable twice its diameter. A core having a maximum height of less than 95 per cent of its diameter before capping or a height less than its diameter after capping shall not be tested.

5.2 End Preparation. The ends of core specimens to be tested in compression shall be essentially smooth, perpendicular to the longitudinal axis, and of the same diameter as the body of the specimen. If necessary, saw or tool the ends of the specimens until the following requirements are met:

5.2.1 Projections, if any, shall not extend more than 0.2 in. above the normal plane

5.2.2 The planes of the ends shall not depart from perpendicularity to the longitudinal axis by more than 5 deg, and

5.2.3 The diameters of the ends shall not depart more than 0.1 in. from the mean diameter of the specimen.

5.3 Moisture Conditioning. Completely submerge the test specimens in water at 73.4 ± 3.0 F (23.0 ± 1.7 C) for at least 40 hr immediately prior to making the compression test. Test the specimens promptly after removal from water storage. During the period between removal from water storage and testing, keep the specimens moist by covering with a wet blanket of burlap or other suitable absorbent fabric (Note 1).

NOTE 1. When the agency for which the testing is being done so directs, cores may be tested in a moist condition other than that achieved by soaking for at least 40 hr. Length-diameter correction factors for dry concrete appear to depart considerably from those applicable to soaked concrete, but they have not been firmly established; therefore, when cores are to be tested dry, their lengths should be twice their diameters and no correction factors should be applied.

5.4 Capping. Before making the compression test, cap the ends of the of the specimens in Conformance with procedure prescribed in the applicable section of the Method of Making and Curing Concrete Compression and Flexure Test Specimens in the field. The capped surfaces of the specimens shall conform to the requirements of PDH 611-

5.5 Measurement. Prior to testing, measure the lengths of the capped specimens to the nearest 0.1 in. Determine the average diameters by averaging two measurements taken at right angles to each other about the mid-height of the specimens. Measure core diameters to the nearest 0.01 in wherever possible, but at least to the nearest 0.1 in. (Note 2).

NOTE 2. Most shot-drilled cores will not be smooth enough to justify measuring of diameters closer than the nearest 0.1 in.

5.6 Testing. Test the specimens in accordance with the applicable provisions of the Method of Test for Compressive Strength of Molded Concrete Cylinders (PTM 604-).

5.7 Calculations. Calculate the compressive strength of each specimen using the computed cross-sectional area based on the average diameter of the specimen. If the ratio of length to diameter of a specimen is appreciably less than two, make allowance for the ratio of length to diameter by multiplying the compressive strength by the applicable correction factor as follows:

Ratio of Length of Cylinder to Diameter $\frac{1}{d}$	Strength Correction Factor
1.75	0.98
1.50	0.97
1.25	0.94
1.00	0.91

NOTE 3. These correction factors apply to lightweight concrete weighing between 100 and 120 lb per cu ft and to normal weight concrete. They are not applicable to autoclaved concrete or to concrete dry at the time of loading.

Values not given in the table shall be determined by interpolation. The correction factors are applicable for nominal concrete strengths from 2000 to 6000 psi.

5.8 Report. Report the results as required by PTM 604 with the following information:

5.8.1 Length of test specimen before and after capping,

5.8.2 Compressive strength to the nearest 10 psi when the diameter is measured to the nearest 0.01 in. and to the nearest 50 psi when the diameter is measured to the nearest 0.1 in., after correction for length-diameter ratio when required,

5.8.3 Direction of application of the load on the specimen with respect to the horizontal plane of the concrete as placed, and

5.8.4 The moisture condition at the time of testing.

6. Reference

AASHO:T 24
astm C 442

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 607
July, 1968
4 Pages

Bureau of Materials Testing & Research

METHODS OF

SAMPLING STONE, SLAG, GRAVEL, SAND AND STONE BLOCK FOR USE AS HIGHWAY MATERIALS

1. SCOPE

1.1 These methods, which are in accordance with AASHO T 2 are intended to apply to the sampling of stone, slag, gravel, sand, and stone block for the following purposes:

Preliminary investigation of sources of supply,
Acceptance or rejection of source of supply,
Inspection of shipments of materials, and
Inspection of materials on the site of the work.

2. SECURING SAMPLES

2.1 Samples of all materials for test shall be taken by the engineer or his authorized representative.

2.2 Sampling is equally as important as the testing, and the sampler shall use every precaution to obtain samples that will show the true nature and condition of the materials which they represent.

3. STONE FROM LEDGES OR QUARRIES

3.1 Inspection

3.1.1 The ledge or quarry face of the stone shall be inspected to determine any variation in different strata. Differences in color and structure shall be observed.

3.2 Sampling and Size of Sample

3.2.1 Separate samples of stone weighing at least 50 lbs. each, and consisting of specimens that are obviously not weathered beyond a degree of usefulness for the purpose intended, shall be obtained from all strata that appear to vary in color and structure. (When the toughness or compression test is required, one piece of each sample shall be not smaller than 6 by 6 by 4 in. in size with the bedding plane plainly marked, and this piece shall be free of seams or fractures). Pieces that have been damaged by blasting shall not be included in the sample.

3.3 Record

3.3.1 The following information shall accompany samples from local ledges that are not commercial sources:

3.3.1.1 Name of owner or seller,

3.3.1.2 Approximate quantity available (if quantity is very large this can be recorded as practically unlimited),

3.3.1.3 Quantity and character of overburden or stripping,

3.3.1.4 Some detailed record of the extent and location of the material represented by each sample (Note 1).

NOTE 1.—A sketch, plan and elevation, showing the thickness and location of the different layers is required for this purpose.

4. FIELD STONE AND BOULDERS

4.1 Inspection

4.1.1 A detailed inspection of the deposits of field stone and boulders, over the area where the supply is to be obtained, shall be made. The different kinds of stone and their condition in the various deposits shall be recorded.

4.2 Sampling

4.2.1 Separate samples shall be selected of all classes of stone that visual inspection indicates would be considered for use in construction. These individual samples shall weigh at least 50 lbs.

4.3 Record

4.3.1 Records accompanying samples of field stone and boulders, in addition to general information, shall contain the following:

4.3.1.1 Location of supply,

4.3.1.2 Approximate quantity available, and

4.3.1.3 The percentages of different classes of stone that were sampled, and the percentages of material that can be rejected by visual examination and may therefore have to be handled and rejected.

5. SAND AND GRAVEL Roadside Production and Bank Run

5.1 Description of Term

5.1.1 Roadside production shall be understood to be the production of materials with portable or semiportable crushing, screening, or washing plants established or reopened in the vicinity of the work on a designated project for the purpose of supplying materials for that project.

5.2 Sampling

5.2.1 Samples shall be so chosen as to represent the different materials, discernible to the sampler, that are available in the deposit. An estimate of the quantity of the different materials shall be made.

5.2.2 If the deposit is worked as an open-face bank or pit, the sample shall be taken by channeling the face vertically, bottom to top, so that it will be representative of the material proposed to be used. Overburden and disturbed material shall not be included in the sample. Test holes shall be excavated or drilled at numerous locations in the deposit to determine the quality of the material and the extent of the deposit. The number and depth of these test holes will depend on the quantity of the material to be used, topography of the area, nature of the deposit, character of the material, and value of the resultant product. Separate samples shall be obtained from the face of the bank and from test holes, in the manner described above, and if visual inspection indicates that there is considerable variation in the material, individual samples shall be selected to represent the material in each well-defined stratum. Otherwise, large samples from each test location shall be obtained and reduced to the proper size by thoroughly mixing and quartering. The size of the samples shall be such that at least 25 lbs. of sand and 75 lbs. of gravel are available for tests, if both constituents are present. If the deposit being investigated does not have an open face, samples shall be obtained entirely from test holes as outlined herein.

5.2.3 In sampling material from stockpiles it is very difficult to insure representative samples, due to the segregation which usually occurs when material is stockpiled, with the coarser particles rolling to the outside base of the pile. When it is necessary to sample stockpiles, every effort should be made to enlist the services of power equipment that is capable of exposing the material at various levels and locations. Separate samples shall be taken from different areas of the stockpile to represent the material in that portion. Test results of the individual samples will indicate the extent of segregation existing in the stockpiles. In sampling sand from stockpiles the outer layer, which may have become dry, causing segregation, shall be removed and a representative sample of the damp sand selected.

5.3 Record

5.3.1 The following information shall accompany samples from roadside production that are not commercial operations:

5.3.1.1 Name of owner or seller,
5.3.1.2 Location of supply,
5.3.1.3 Approximate quantity available,
5.3.1.4 Quantity and character of overburden,
5.3.1.5 Some detailed record of the extent and location of the material represented by each sample. (Note 1)

6. SAND, GRAVEL, STONE, AND SLAG Commercial Sources

6.1 Sampling for Quality

6.1.1 Where practicable, samples from commercial sources to be tested for quality shall be obtained from the finished product. Otherwise, the sample shall be taken in accordance with the procedure described in Sections 3.2.1, 4.2.1 or 5.2.1, whichever is applicable.

6.1.2 Samples to be tested for abrasion loss shall be obtained from commercially prepared material.

6.2 Sampling at Plant

6.2.1 A general inspection of the plant and a record of the screening facilities shall be made. The samples shall preferably be taken at some suitable location that will insure positive representative sampling as the railroad cars, barges, boats, or trucks are being loaded from stockpiles or bins. In order to determine variations in the grading of the material separate samples shall be obtained at different times while the material is being loaded. If the samples are taken from a bin, they shall be taken from the entire cross-section of the flow of material as it is being discharged. At the beginning of the discharge from the bins, sufficient material should be permitted to flow to insure normal uniformity before the sample is selected.

6.3 Sampling at Delivery

6.3.1 Separate samples shall be taken from as many points in the unit of shipment as is necessary to represent the material, realizing the probability of segregation as the material was loaded. These separate samples will usually be combined to form a composite sample and this sample shall, if necessary, be reduced by quartering, but if information on variation is desired the separate samples shall be tested.

Samples of coarse aggregate from stockpiles should be taken at or near the top of the pile, at or near the base of the pile, and at or near an intermediate point. A board shoved into the pile just above the point of sampling will aid in preventing further segregation during sampling. Samples from railroad cars should be taken from three or more trenches dug across the car at points that appear on the surface to be representative of the material. The bottom of the trench should be at least 1 ft. below the surface of the aggregate at the sides of the car and approximately 1 ft. wide at the bottom. The bottom of the trench should be practically level. Equal portions should be taken at seven equally spaced points along the bottom of the trench by pushing a shovel downward into the material and not by scraping horizontally. Two of the seven points should be directly against the sides of the car.

6.3.2 Samples from trucks, barges, or boats should be taken in the same manner as described for railroad cars, except that the number of trenches shall be adjusted according to the size of the transportation unit and the tonnage involved.

6.3.3 Fine aggregate may be sampled as described in Sections 6.3.1 and 6.3.2 or by means of a sampling tube approximately 1¼-in. in diameter by 6 ft., which with a little practice, will be found to hold damp sand forced into it when inserted into the fine aggregate to be sampled. Five to eight insertions of the tube into the unit to be sampled will furnish approximately 10 lbs. of fine aggregate.

6.3.4 Where a test is to be made for size only, it is recommended that tests be made in the field in order not to delay decision on the use of the material. Samples shall also be sent to the laboratory for check tests.

6.4 Number and Size of Samples

6.4.1 The number of samples required depends on the intended use of the material, the quantity of material involved, and the variations both in quality and size of the aggregate. A sufficient number of samples shall be obtained to cover all variations in the material.

6.4.2 The sample sizes and quantities must be predicated on the type and number of tests to which the material is to be subjected and sufficient material obtained to provide for the proper execution of these tests. All standard acceptance and control tests are covered by methods of the Pennsylvania Department of Highways and specify the quantity of sample required for each specific test as shown in Section 3, PTM 616.

7. MISCELLANEOUS MATERIALS

7.1 Sampling

7.1.1 Samples of slag sand, stone sand, screenings, and all other similar materials shall be sampled in the same manner as prescribed for the materials of similar size and classification.

8. STONE BLOCK

8.1 Sampling

8.1.1 Samples of stone block shall be taken as directed.

8.2 Size of Sample

8.2.1 The sample shall consist of at least six blocks and the bedding plane shall be marked on at least two of these.

9. MARKING AND SHIPPING SAMPLES

9.1 Marking

9.1.1 Each sample or separate container shall be accompanied by a card or regular form, preferably in the container, giving the following information:

9.1.1.1 By whom taken, and the official title of the sampler,
9.1.1.2 By whom submitted,
9.1.1.3 Source of supply, and in case of commercial supplies, daily production,
9.1.1.4 Proposed use for the material.
9.1.1.5 Geographic location, and shipping facilities.

9.2 Shipping Samples

9.2.1 Coarse aggregate shall be shipped in a secure container or sample bag.

9.2.2 Fine aggregate or samples containing fine sizes shall be shipped in a tight container or closely woven bag so there will be no loss of the finer particles.

9.2.3 Stone block shall be securely crated.

End of Text PTM 607
Reference AASHO T 2

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 609
October 1971
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

UNIT WEIGHT OF AGGREGATE

1. Scope

1.1 This method of test covers the procedures for determining the unit weight of fine, coarse, or mixed aggregates, and is a modification of AASHO T 19.

2. Apparatus

The apparatus shall consist of the following:

2.1 Balance — A balance or scale accurate within 0.3 percent of the test load at any point within the range of use. The range of use shall be considered to extend from the weight of the measure empty to the weight of the measure plus its contents at 100 lb/ft.^{3}

2.2 Tamping Rod — A round, straight steel rod, 5/8 in. in diameter and approximately 24 in. in length, having one end rounded to a hemispherical tip of the same diameter as the rod.

2.3 Measure — A cylindrical metal measure, provided with handles which shall be located on opposite sides and approximately 2 in. from the top rim. It shall be watertight, with the top and bottom true and even, preferably machined to accurate dimensions on the inside, and sufficiently rigid to retain its form under rough usage. The top rim shall be smooth and plane, and shall be parallel to the bottom, (Note 1). Measures of the two larger sizes listed in Table 1 shall be reinforced around the top with a metal band, to provide an overall wall thickness of not less than 0.20 in. in the upper 1½ in. (Note 2). The capacity and dimensions of the measure shall conform to the limits in Table 1 or 2 (Note 3).

2.4 Oven — Capable of maintaining a temperature of 110 ± 5 C (230 ± 9 F)

NOTE 1 — The top rim is satisfactorily plane if a 0.01-in. feeler gage cannot be inserted between the rim and a piece of ¼ in. or thicker plate glass laid over the measure. The top and bottom are satisfactorily parallel if the slope between pieces of plate glass in contact with the top and bottom does not exceed 1 percent in any direction.

NOTE 2 — Steel band is not required if wall thickness of measure is 0.25 in or greater.

NOTE 3 — Dimensional tolerances and thicknesses of metal prescribed here are intended to be applied to measures acquired after January 1, 1968. Measures acquired before that date may conform either to this standard or to Section 2.3 of the previous Pa. Test Method No. 609 dated August 1968.

TABLE I DIMENSIONS OF MEASURERS*

Capacity Cu.Ft.	Inside Diameter In.	Inside Height In.	Minimum Thickness of Metal (Inches) Bottom	Wall	Maximum Nominal Size of Aggregate, (Inches) **
1/10	6.0 ± 0.1	6.1 ± 0.1	0.20	0.10	½
1/3	8.0 ± 0.1	11.5 ± 0.1	0.20	0.10	1
½	10.0 ±0.1	11.0 ± 0.1	0.20	0.12	1½
1	14.0 ±0.1	11.2 ± 0.1	0.20	0.12	4

*The indicated size of container may be used to test aggregates of a maximum nominal size equal to or smaller than that listed.

**Based on sieves with square openings.

3. Calibration of Measure

3.1 Fill the measure with water at room temperature and cover with a piece of plate glass in such a way as to eliminate bubbles and excess water.

3.2 Determine the net weight of water in the measure to an accuracy of about ± 0.1 per cent (1/10 cu. ft. : ± 0.005 lb., 1/3 cu. ft. : 0.03 lb., 1cu. ft. : ± 0.06 lb.)

3.3 Measure the temperature of the water and determine its unit weight from Table 3, interpolating if necessary.

3.4 Calculate the factor for the measure by dividing the unit weight of the water by the weight required to fill the measure.

TABLE 3 UNIT WEIGHT OF WATER

Temperature deg F	deg C	lb/ft^3
60	15.6	62.366
65	18.3	62.336
70	21.1	62.301
75	23.9	62.261
80	26.7	62.216
85	29.4	62.166

4. Sample

4.1 The sample of aggregate shall be dried to essentially constant weight, preferably in an oven, at 230 ± 9 F of 110 ± 5 C and thoroughly mixed. (note 4).

NOTE 4 — When making Loose Weight Determination of Coarse Aggregates for use in portland cement concrete mix design computations, the aggregate shall be in a stockpile-wet condition.

5. Rodding Procedure

5.1 The rodding procedure will be used for aggregates having a maximum size of 1½ in. or less, except that the jigging procedure will be used for open-hearth slag of all sizes.

5.2 Fill the measure one-third full and level the surface with the fingers. Rod the layer of aggregate with 25 strokes of the tamping rod evenly distributed over the surface. Fill the measure two-thirds full and again level and rod as above. Finally, fill the measure to overflowing and again rod as above. Level the surface of the aggregate with the fingers or a straightedge in such a way that any slight projections of the larger pieces of the coarse aggregate approximately balance the larger voids in the surface below the top of the measure.

5.3 In rodding the first layer, do not allow the rod to strike the bottom of the measure forcibly. In rodding the second and third layers, use only enough force to cause the tamping rod to penetrate the previous layer of aggregate.

5.4 Determine the net weight of the aggregate in the measure to the nearest 0.1%. Multiply this weight by the factor calculated as described in 3.4. The product is the compact unit weight of the aggregate.

6. Jigging Procedure

6.1 The jigging procedure will be used for aggregates having a maximum size greater than 1½ in. and not to exceed 4 in. except that the jigging procedure will be used for open-hearth slag of all sizes.

6.2 Fill the measure in three approximately equal layers as described in 5.2, compacting each leayer by placing the measure on a firm base, such as a cement-concrete floor, raising opposite sides alternately about 2 in., and allowing the measure to drop in such a manner as to hit with a sharp, slapping blow. The aggregate particles, by this procedure, will arrange themselves in a densely compacted condition. Compact each layer by dropping the measure 50 times in the manner described, 25 times on each side. Level the surface of the aggregate with the fingers or a straightedge in such a way that any slight projection of the larger pieces of the coarse aggregate approximately balance the larger voids in the surface below the top of the measure.

6.3 Determine the net weight of the aggregate in the measure to the nearest 0.1 percent. Multiply this weight by the factor calculated as described in 3.4. The product is the compact unit weight of the aggregate.

LOOSE WEIGHT DETERMINATION

7. Shoveling Procedure

7.1 The shoveling procedure is applicable to aggregates having a maximum size of 4 in. or less and is the procedure generally desired for determining the unit weight of aggregate when making the calculations for portland cement concrete mix designs.

7.1.1 Fill the measure to overflowing by means of a shovel or scoop, discharging the aggregate from a height not to exceed 2 in. above the top of the measure, giving the measure ¼ turn after each shovelful is placed. Exercise care to prevent, so far as possible, segregation of the particle sizes of which the sample is composed. Level the surface of the aggregate with the fingers or a straightedge in such a way that any slight projections of the larger pieces of the coarse aggregate approximately balance the larger voids in the surface below the top of the measure.

7.1.2 Determine the net weight of the aggregate in the measure to the nearest 0.1 percent. Multiply this weight by the factor calculated as described in 3.4. The product is the loose unit weight of the aggregate.

8. Reproducibility of Results

8.1 Results by an operator using the same sample and procedure should check within 1 percent.

9. Reference

AASHO T19-

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 611
February 1971
6 Pages

Bureau of Materials, Testing & Research

Method of Test for

MAKING AND CURING CONCRETE COMPRESSION AND FLEXURAL TEST SPECIMENS IN THE FIELD

1. Scope

1.1 This method covers procedures for making and curing specimens of concrete sampled from concrete being used in construction, and is in accordance with AASHO T 23.

2. Apparatus

2.1 Molds for Compression Test Specimens. The molds shall be cylindrical, have nonabsorbent surfaces and shall be substantial enough to hold their shape during the molding of test specimens (Note 1). The plane of the rim of the mold shall be normal to its axis. The molds shall not vary from the prescribed diameter (Section 6) by more than 1/16 in. nor from the prescribed length (Section 6) by more than 1/4 in. No two diameters shall differ more than 1/8 in. from each other. Reusable metal molds shall be provided with a machined metal base plate. Molds made of material other than metal shall be provided with a base plate or bottom, with means for securing it to the mold at a right angle to the axis of the cylinder. The mold shall stand upright on its base plate or bottom and the top end shall be open to receive the concrete. The assembled mold and base plate or bottom shall be oiled with a light coat of mineral oil before use. The assembly shall be watertight, and a suitable sealant used where necessary to prevent leakage through the joints. Paraffined cardboard molds, and sheet metal molds shall comply with the requirements of the Specification for Single-Use Molds for Forming 6 by 12-in. Concrete Compression Test Cylinders (AASHO M 205).

NOTE 1. Satisfactory molds may be made from cold-drawn, seamless steel tubing or from steel pipe. These tubular sections shall be cut to the proper length, split at one side parallel to the axis, and fitted with a circumferental metal band and bolt for closing. Split molds should be machined inside, to ensure perfectly round shape, after splitting and clamping. Satisfactory molds may also be made from iron or steel castings. Molds made from formed sheet metal must be used with care to ensure that they are not deformed more than the stipulated tolerances. Paraffined cardboard molds should be used only under expert supervision. The use of a tube of heavy gage metal around sheet steel or cardboard molds when the specimen is being molded will preserve the dimersional integrity of the form.

2.2 Molds for Flexure Test Specimens. Molds for flexure test specimens shall be rectangular and of the dimensions specified in Section 9. The mold shall be at least 2 in. longer than the length of span prescribed in the Method of Test for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading) (PTM 605). Molds shall be watertight and made of rigid, nonabsorptive material. Means shall be provided for securing the base plate firmly to the mold. The inside surfaces of the mold shall be smooth and free from holes, indentations, or ridges. The sides, bottom, and ends shall be at right angles and shall be straight and true so that the specimen will not be warped. Maximum variation from the nominal cross-section shall not exceed 1/8 in. The assembled mold and base plate shall be lightly coated with mineral oil before use.

2.3 Tamping Rod. The tamping rod shall be a round, straight steel rod, 5/8 in. in diameter and approximately 24 in. in length, having one end rounded to a hemispherical tip, the diameter of which is 5/8 in.

2.4 Vibrators. Internal vibrators may have rigid shafts or flexible shafts, preferably powered by electric motors. The frequency of vibration shall be 7000 rpm or greater. The outside diameter of the vibrating element shall be not smaller than 0.75 in. nor greater than 1.50 in. The length of the shaft should be at least 24 in. External vibrators may be either of two types-table or plant (Note 2). The frequency for external vibrators shall be 3600 rpm or higher (preferably higher). For both table and plank vibrator provision shall be made for clamping the mold securely to the apparatus. A tachometer should be used to check frequency of vibration.

NOTE 2. Vibratory impulses are frequently imparted to table or plank vibrators through electro-magnetic means, or by use of an eccentric weight on the shaft of an electric motor or on a separate shaft driven by a motor.

2.5 Small Tools. Tools and items such as shovels, pails, rubber mallet, trowels, wood float, blunted trowels, straight-edge, feeler gage, scoops, and rulers shall be provided.

2.6 Slump Apparatus. The apparatus for measurement of slump shall conform to the requirements of the Method of Test for Slump of Portland Cement Concrete (PTM 600).

2.7 Sampling and Mixing Receptacle. A suitable pan, wheelbarrow, or flat, clean nonabsorbent mixing board of sufficient capacity to allow easy mixing by shovel or trowel of the entire sample shall be provided.

2.8 Air Content Apparatus. The apparatus for measuring air content shall conform to the requirements of the Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method (PTM 612). or the Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method (PTM 615).

3. Sampling Concrete

3.1 Samples of concrete for test specimens shall be taken in accordance with the Method of Sampling Fresh Concrete (PTM 601). The place of depositing the load of concrete that was sampled shall be noted in the job records.

4. Slump and Air Content

4.1 Slump. The slump of each load of concrete sampled for test specimens shall be measured, immediately after sampling, in accordance with PTM 600). Concrete used for the slump test shall be discarded.

4.2 Air Content. The air content of each load sampled for test specimens shall be determined in accordance with either PTM 615 or PTM 612 . Concrete used for determination of air content shall be discarded.

5. Molding Specimens

5.1 Place of Molding. Specimens shall be molded as near as practicable to the place where they are to be stored during the first 24 hr. If it is not practicable to mold the specimens where they will be stored, they may be moved to the place of storage within 15 min. after being struck off (Note 3). All jarring, striking, tilting, or scarring of the surface of the specimens shall be avoided when moving specimens to a safe place.

NOTE 3. A trowel slipped under the bottom of a cardboard mold will aid in preventing distortion of the bottom during moving.

5.2 Methods of Consolidation. Concretes at different slump levels require different methods of consolidation to prepare satisfactory test specimens. The selection of the method of consolidation shall be based on the slump, unless the method of consolidation of test specimens is stated in the specifications under which the work is being performed. The two methods of consolidation are rodding and internal or external vibration. Concretes with slump greater than 3 in. shall be rodded. Concretes with slump of less than 1 in. shall be consolidated by vibration, concretes with slump of 1 – 3 in. may be consolidated by either vibration or rodding. (Note 4).

NOTE 4. Concrete with zero slump and relatively dry mixtures used in pipe and block plants may require the use of special means for consolidation. These concretes are not covered by this method.

5.3 Placing the Concrete. The concrete shall be placed in the molds in two or three layers (Sections 7.1 and 7.2 and 10.1) using a scoop or blunted trowel. In placing each portion of concrete, the scoop or trowel shall be moved around the top edge of the mold as the concrete is discharged in order to ensure a symmetrical distribution of the concrete and minimize segregation of the coarse aggregate within the mold. The concrete may be further distributed by use of a tamping rod prior to the start of consolidation. After consolidation by any of the methods, the surface of the concrete shall be struck off without undue manipulation using a straightedge or trowel, the beams finished with a wood float and all specimens covered immediately with glass or metal plates, polyethylene film, or other covering to prevent evaporation.

5.4 Relation between Specimen Size and Aggregate Size. The diameter of the cylindrical specimen or the minimum cross-section dimension of a beam shall be at least three times of the maximum nominal size of the coarse aggregate in the concrete. Occasional oversize aggregate particles may be removed by hand picking during the molding of specimens.

COMPRESSION TEST SPECIMENS

6. Specimens

6.1 Size of Specimens. Compression test specimens shall be cylindrical, with a length equal to twice the diameter. The standard specimen shall have a diameter of 6 in. if the coarse aggregate does not exceed 2 in. in nominal size. Specimens smaller than 6 in. in diameter shall not be made from concrete sampled in the field.

6.2 Molding Specimens. Specimens shall be molded as prescribed in Section 5. An inverted slump cone or suitable funnel may be used to direct concrete into the mold.

7. Method of Consolidation

7.1 Rodding. The concrete shall be placed in the mold in three layers of approximately equal volume. Using the tamping rod with the hemispherical tip in contact with the concrete, each of the layers shall be rodded 25 strokes. The bottom layer shall be rodded throughout its depth. The strokes shall be distributed uniformly over the cross-section of the mold and for each upper layer shall penetrate about 1 in. into the underlying layer. If voids are left by the tamping rod, the sides of the mold shall be tapped lightly to close the voids.

7.2 Vibration. A standard duration of vibration shall be observed for the particular kind of concrete, vibrator and specimen mold involved. Vibration shall be continued only long enough to achieve proper consolidation of the concrete. Over vibration may cause segration. The mold shall be filled and vibrated in two approximately equal layers. All of the concrete for each layer shall be placed in the mold before starting vibration of that layer. The second layer shall be added so as to avoid overfilling by more than 1/4 in. After vibrating the second layer, enough concrete shall be added and worked into the surface concrete with a trowel to overfill the mold about 1/8 in. and then struck off. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Usually, sufficient vibration has been applied as soon as the surface of the concrete becomes relatively smooth in appearance.

7.2.1 Internal Vibration. Three insertions of the vibrator at different points shall be used for each layer. In compacting the bottom layer, the vibrator shall not be allowed to rest on the bottom or touch the sides of the mold. The vibrator shall penetrate through the second layer and into the bottom layer approximately 1 in. Care should be taken that the vibrator is withdrawn in such a manner that no air pockets are left in the specimen.

10.2 Rodding. Each layer shall be rodded evenly over its area 50 times. The bottom layer shall be rodded throughout its depth. The upper layers shall be rodded so that the strokes penetrate approximately 1 in. into the immediately underlying layer. The top layer shall slightly overfill the mold. After each layer is rodded, the concrete shall be spaded along the sided and ends of the mold with a trowel or other suitable tool. The sides of the mold shall be tapped with a rubber mallet to close the voids.

10.3 Vibration. Vibration shall be continued only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Usually, sufficient vibration has been applied when the surface of the concrete becomes relatively smooth in appearance.

10.3.1 Internal Vibration. The vibrator shall be inserted at intervals not exceeding 6 in. along the center line of the long dimension of the specimen. For specimens wider than 6 in., alternating insertions along two lanes shall be used. The vibrator shall not be allowed to rest on the bottom or strike the sides of the mold. The vibrator shall penetrate into the bottom layer approximately 1 in. Care shall be taken that the vibrator is withdrawn in such a manner that no air pockets are left in the specimen.

10.3.2 External Vibration. When external vibration is used, care shall be taken to ensure that the mold is rigidly attached to or securely held against the vibrating element or vibrating surface.

CURING COMPRESSION AND FLEXURAL TEST SPECIMENS

11. Specimens

11. Specimens for Checking the Strength of Concrete for Trial Mix Designs. Molds shall be placed on a rigid horizontal surface free from vibration and other disturbances. During the first 24 ± 2 hr. all test specimens shall be stored under conditions that maintain the temperature immediately adjacent to the specimens in the range of 60 to 80 F (16 to 27 C) and prevent loss of moisture from the specimens. Storage temperatures may be regulated by means of ventilation or by evaporation of water from sand or burlap (Note 11), or by using heating devices such as stoves, electric light bulbs, or thermostatically—controlled heating cables. A temperature record of the specimens shall be established by means of maximum—minimum thermometers. Specimens may be stored in tightly constructed, firmly—braced wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather, or by other suitable methods, provided the foregoing requirements limiting specimen temperature and moisture loss are met. Specimens formed in cardboard molds should not be stored for the first 24 ± 2 hr. in contact with wet sand or wet burlap or under any other conditions that will allow the mold to absorb water. Cardboard molds can be covered with a layer of polyethylene sheeting and then wet burlap placed over them. After 24 ± 2 hr. of curing under the above conditions, the specimens shall be removed from the molds and stored in a saturated lime solution at a temperature within the range of 73 ± 3 F (23 ± 1.7 C) until the time of test, or in a moist condition (Note 8) in a fog room at the previously mentioned temperature.

Specimens should be protected from dripping or running water. At the end of the curing period, between the time the specimen is removed from the curing until testing is completed, drying of the surfaces of the specimens shall be prevented (Note 9). Specimens shipped from the field to the laboratory for testing shall be packed in a sturdy wooden box or other suitable container surrounded by wet sawdust or wet sand and protected from freezing during shipment. Upon receipt by the laboratory they shall be placed immediately in moist curing at 73 ± 3 F. (Note 10).

NOTE 7. The temperature within damp sand and under wet burlap or similar materials will always be lower than the temperature in the surrounding atmosphere if evaporation takes place.

NOTE 8. A moist condition is that in which free water is maintained on the surface of the specimens at all times.

NOTE 9. Relatively small amounts of drying of the surface of flexural specimens induce tensile stresses in the extreme fibers that will markedly reduce the indicated flexural strength.

7.2.2 External Vibration. When external vibration is used, care shall be taken to ensure that the mold is rigidly attached to or securely held against the vibrating element or surface.

8. Capping Specimens

8.1 General Provisions. The ends of all compression test specimens that are plane within 0.002 in. shall be capped or ground plane. Capped surfaces shall not depart from a plane by more than 0.002 in. The planeness of the caps of every tenth specimen shall be checked by means of a straightedge and feeler gage, making a minimum of three measurements on different diameters. The capped surface of the specimen in contact with the lower bearing block of the testing machine shall not depart from perpendicularity to the axis of the cylinder by more than 0.5 deg (approximately equivalent to 1/8 in. in 12 in.) and the combined departure to the two capped surfaces from perpendicularity to the axis shall not exceed 3 deg. Caps shall be made as thin as practicable. Any capping material when tested as 2-in. cubes of the same age and composition as the caps of the concrete cylinder shall develop compressive strength greater than the anticipated strength of the concrete cylinder (Note 5). Caps made from mixtures of sulfur type materials shall be formed against metal plates. Metal plates shall be at least 1 in. greater in diameter than the specimen and shall not depart from a plane by more than 0.002 in. Adhesion of the capping material to the capping plate may be avoided by coating the plate with light machine oil or mineral oil. Suitable alignment devices should be used in conjunction with the plates to ensure that the specified perpendicularlty of the caps and the axis of the specimen is attained. Surface roughness of newly finished metal plates shall not exceed that set forth in Table 4 of ASA B46.1 on Physical Specimens of Surface Roughness and Lay of 125 micro-in. for any type of surface and direction of lay. The surface when new shall be free from gouges, grooves, or indentations beyond those caused by the finishing operations incidental to a surface roughness of 125 micro-in.

NOTE 5. The compressive strength of mixtures of sulfur and granular materials may be determined in accordance with Section 7.1 of the Specifications for Sulfur Mortar (ASTM Designation: C 287).

8.2 Sulfur and Granular Materials. Proprietary or laboratory prepared mixtures of sulfur and granular materials may be used and caps should be allowed to harden at least ½ hr. before the specimens are tested. A melting pot equipped with automatic temperature controls shall be used for heating these mixtures.

NOTE 6. Caution. Melting pots equipped with peripheral heating will ensure against accidents happening when reheating cooled sulfur mixtures which have a crusted-over surface. When using melting pots that are not so equipped, care should be exercised to avoid the build-up of pressure under the hardened surface crust by means of a metal rod which contacts the bottom of the pot and projects above the surface of the fluid sulfur mix as it cools. The rod should be of sufficient size to conduct enough heat to the top on reheating to melt a ring around the rod first and thus avoid the development of pressure.

Sulfur melting pots should be used under a hood to exhaust the fumes to outdoors. The proper range of pouring temperature is from 265 to 290 F. Since the flash point of sulfur is approximately 440 F., the mixture may ignite due to overheating, and heating over an open flame is dangerous. Should the mixture start to burn, covering will snuff out the flame. If the flame is extinguished immediately, the sulfur mixture may be used for capping.

FLEXURE TEST SPECIMENS

9. Size of Specimens

9.1 The flexure test of specimens shall be rectangular beams 6"x8"x22". Maximum variation from the nominal cross section shall not exceed 1/8 in.

10. Placing and consolidation

10.1 Placing the Concrete. The concrete shall be placed in the molds using a scoop or shovel. Molds 8 in. or less in depth shall be filled in two approximately equal layers. Effort shall be made to minimize segregation while filling the molds. Concrete shall be symetrically distributed within the mold. The concrete may be distributed by means of the tamping rod prior to start of consolidation.

NOTE 10. **Under no conditions shall the specimens be disturbed or moved between 15 min. and 24 ± 2 hr. after molding. Any disturbance of the specimen may cause a reduction in final test results.**

11.2 Specimens for Field Control. Specimens shall be placed on a rigid horizontal surface free from vibration and other disturbances. During the first 24 ± 2 hr. all test specimens shall be sotred under conditions that maintain the temperature immediately adjacent to the specimens in the range of 60 to 80 F (16 to 27C) and prevent loss of moisture from the specimens. Storage temperatures may be regulated by means of ventilation or by evaporation of water from sand or burlap (Note 7), or by using heating devices such as stoves, electric light bulbs, or thermostatically—controlled heating cables. A temperature record of the specimens shall be established by means of maximum-minimum thermometers. Specimens may be stored in tightly constructed, firmly-braced wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather, or by other suitable methods, provided the foregoing requirements limiting specimen temperature and moisture loss are met. Specimens formed in cardboard molds should not be stored for the first 24 ± 2 hr. in contact with wet sand or wet burlap or under any other conditions that will allow the mold to absorb water. Carboard molds can be covered with a layer of polyethylene sheeting and then wet burlap placed over them. After 24 ± 2 hr. of curing under the above conditions, the specimens shall be stored in or on the structure as near to the point of use as possible, and shall receive, insofar as practicable, the same protection from the elements on all surface as is given to the portions of the structure which they represent. Specimens shall be tested in the moisture condition resulting from the specified curing treatment. (Note 8) (Note 9). To meet these conditions the specimens shall be removed from the molds at the time of removing formwork. (Note 11).

NOTE 11. **The specimens shall not be moved or distrubed during the period of time 15 min. and 24 + 2 hr. after molding.**

12. Reference

AASHO T-23
ASTM C 31

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 612
August 1968
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE VOLUMETRIC METHOD

1. Scope

1.1 This method of test covers the procedure for determining the air content of freshly mixed concrete containing any type of aggregate, whether it be dense, cellular, or lightweight, and is in accordance with AASHO T 196.

2. Apparatus

2.1 Air Meter. An air meter consisting of a bowl and a top section (Fig. 1) conforming to the following requirements:

2.1.1 Bowl. The bowl shall be constructed of machined metal of such thickness as to be sufficiently rigid to withstand normal field use and of such composition as not to be readily attacked by cement paste. The bowl shall have a diameter equal to 1 to 1.25 times the height and be constructed with a flange at or near the top surface. Bowls of not less than 0.20 cu. ft. shall be employed for general use with structural or pavement concrete containing aggregate with maximum size of 2 in. or less.

NOTE 1--A bowl of not less than 0.075 cu. ft. may be used for routine work, but results obtained with such small apparatus should be checked against those obtained with the 0.20 cu. ft. capacity bowl in case of dispute or doubt of accuracy of results.

2.1.2 Top Section. The top section shall be constructed of machined metal of thickness sufficiently rigid to withstand normal field use and of composition not readily attacked by cement paste. The top section shall have a capacity approximately the same as the bowl and shall be equipped with a flexible gasket and with hooks or lugs to attach to the flange on the bowl to make a water-tight connection. The top section shall be equipped with a glass-lined or transparent plastic neck, graduated in increments not greater than 0.5 percent from 0 at the top to 9 percent, or more, of the volume of the bowl. The upper end of the neck shall be threaded and equipped with a screw cap having a gasket to make a watertight fit.

2.2 Funnel. A metal funnel with a spout of a size permitting it to be inserted through the neck of the top section and long enough to extend to a point just above the bottom of the top section. The discharge end of the spout shall be so constructed that when water is added to the container there will be a minimum disturbance of the concrete.

2.3 Tamping Rod. A round, straight steel rod, 5/8 in. in diameter and approximately 24 in. in length, having the tamping end rounded to a hemispherical tip the diameter of which is 5/8 in.

2.4 Strike-off Bar. A steel bar approximately ¼ by 1 by 18 in. long.

2.5 Measuring Cup. A metal cup having a capacity equal to 1.0 percent of the volume of the bowl of the air meter.

2.6 Syringe. A small rubber bulb syringe having a capacity at least that of the measuring cup.

2.7 Pouring Vessel. A metal or glass container of approximately 1-qt. capacity.

2.8 Trowel. A blunt-nosed brick mason's trowel.

2.9 Scoop. A small metal scoop.

3. Calibration of Apparatus

3.1 The volume of the bowl of the air meter, in cu. ft., shall be determined by accurately weighing the amount of water at 70 F (21.1 C) required to fill it, and dividing this weight by the unit weight of water at 70 F (21.1 C), namely 62.30 lb. per cu. ft. A glass plate shall be used to cover the bowl to remove excess water and to insure that the container is full.

3.2 The accuracy of the graduations on the neck of the top section of the air meter shall be determined by filling the assembled measuring bowl and top section with water to the level of the mark for any air content. A quantity of water at 70 F (21.1 C) equal to 1.0 percent of the volume of the bowl, shall be added to the water already in the neck. The height of the water column shall increase by an amount equivalent to 1.0 percent of air.

3.3 The volume of the measuring cup shall be checked by adding one cupful of water to the assembled apparatus in the manner described in Paragraph 3.2. Such addition shall increase the height of the water column by an amount equivalent to 1.0 percent of indicated air.

4. Sample

4.1 A representative sample of concrete to be tested shall be obtained in accordance with the Method of Sampling Fresh Concrete. PTM 601-

5. Procedure

5.1 Rodding and Tapping. Using the scoop, aided by the trowel if necessary, fill the bowl with freshly mixed concrete in three layers of equal depth. Rod each layer 25 times with the tamping rod, and tap the sides of the bowl 10 to 15 times after each rodding as outlined in Section 5 of the Method of Test for Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete, PTM 613.

5.2 Striking Off. After placement of the third layer of concrete in accordance with Paragraph 5.1, strike off the excess concrete with the strike-off bar until the surface is flush with the top of the bowl. Wipe the flange of the bowl clean.

5.3 Adding Water. Clamp the top section into position on the bowl, insert the funnel, and add water until it appears in the neck. Remove the funnel and adjust the water level, using the rubber syringe, until the bottom of the meniscus is level with the zero mark. Attach and tighten the screw cap.

5.4 Agitating and Rolling. Invert and agitate the unit until the concrete settles free from the base; and then, with the neck elevated, roll and rock the unit until the air appears to have been removed from the concrete. Set the apparatus upright, jar it lightly, and allow it to stand until the air rises to the top. Repeat the operation until no further drop in the water column is observed.

5.5 Dispelling Bubbles. When all the air has been removed from the concrete and allowed to rise to the top of the apparatus; remove the screw cap. Add, in small increments, one measuring cupful of isopropyl alcohol, using the syringe to dispel the foamy mass on the surface of the water.

5.6 Reading. Make a direct reading of the liquid in the neck, reading to the bottom of the meniscus, and estimating to the nearest 0.1 percent.

6. Calculation

6.1 Calculate the air content of the concrete in percent by adding to the reading from Section 5.6 the amount of alcohol used in accordance with Section 5.5

7. Reference

AASHO T 196-
ASTM C 173-

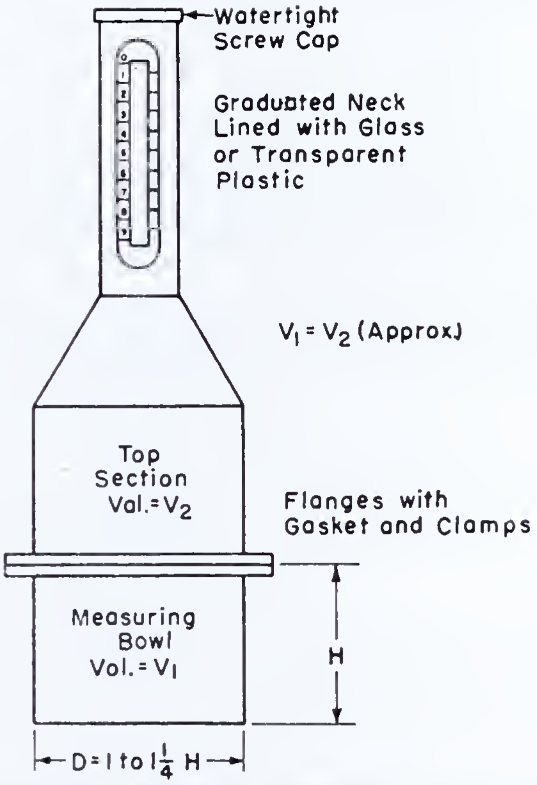


Fig. 1.—Apparatus for Measuring Air Content of Fresh Concrete by Volumetric Method.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 613
August 1968
4 Pages

Bureau of Materials, Testing & Research

Method of Test for

WEIGHT PER CUBIC FOOT, YIELD, AND AIR CONTENT (GRAVIMETRIC) OF CONCRETE

1. Scope

1.1 This method of test covers the procedure for determining the weight per cubic foot of freshly mixed concrete and gives formulas for calculating: the volume of concrete produced from a mixture of known quantities of the component materials; the yield, that is, the volume of concrete per unit volume of cement; the actual cement factor; and the air content of the cement, and is in accordance with AASHO T-121·

NOTE 1--This method of calculating air content is of value when equipment is not available for making the test in accordance with a more convenient method such as PTM 615· . This gravimetric method is not applicable for concrete or mortars made with highly porous aggregates.

2. Apparatus

The apparatus shall consist of the following:

2.1 Balance. A balance or scale sensitive to 0.1 lb.

2.2 Tamping Rod. A straight metal rod, 5/8 in. in diameter and approximately 24 in. in length having the tamping end rounded to a hemispherical tip the diameter of which is 5/8 inch.

2.3 Measure. A cylindrical metal measure, preferably provided with handles. The measure shall be watertight, preferably machined to accurate dimensions on the inside. It shall be reinforced around the top with a No. 10 to No. 12 U.S. gage steel band 1½ in. in width. Depending upon the maximum nominal size of the coarse aggregate in the concrete, the measures required shall have capacities of ½ or 1 cu. ft. and shall conform to the requirements prescribed in Table I.

TABLE I. DIMENSIONAL REQUIREMENTS FOR CYLINDRICAL MEASURES

Capacity cu. ft.	ID Inches	IH Inches	Thickness U.S. Gage	Aggregate Size
1/2	10.00	11.00	No. 10 to 12	up to 2 in.
1	14.00	11.23	No. 10 to 12	over 2 in.

3. Calibration of Measure

3.1 The measure shall be calibrated by accurately determining the weight of water at 62 F (16.7 C) required to fill it (Note). The factor for any measure shall be obtained by dividing the unit weight of water at 62 F (16.7 C), namely, 62.4 lb. per cu. ft., by the weight (in pounds) of water at 62 F (16.7 C) required to fill the measure.

NOTE 2--Accurate filling of the measure may be secured by the use of a glass cover plate.

4. Sample

4.1 The sample of freshly-mixed concrete shall be obtained in accordance with the Standard Method of Sampling Fresh Concrete, PTM 601·

5. Procedure

5.1 Sequence of Operations. The measure shall be filled to one-third of its capacity and the mass of concrete rodded with the number of strokes prescribed in Paragraph 5.2, evenly distributted over the cross-section. The measure shall then be tapped, and filled to two-thirds of its capacity, the mass of concrete again rodded, the measure tapped as before, and finally filled to overflowing, rodded and tapped as before.

5.2 Rodding. In rodding the first layer, the rod shall not strike forcibly the bottom of the measure. In rodding the second and final layers, only enough force shall be used to cause the rod to penetrate the surface of the previous layer. When the ½-cu. ft. measure is used, each layer shall be rodded with 25 strokes, and when the 1-cu. ft. measure is used each layer shall be rodded with 50 strokes.

5.3 Tapping. The exterior surface of the measure shall be tapped smartly 10 to 15 times or until no large bubbles of air appear on the surface of the rodded layer.

5.4 Strike-off, Cleaning, and Weighing. After consolidation of the concrete, the top surface shall be struck off and finished smoothly using great care to leave the measure just level full. All excess concrete shall then be cleaned from the exterior and the filled measure weighed to the nearest 0.1 lb.

6. Calculations

6.1 Weight per Cubic Foot. The net weight of the concrete shall be calculated by subtracting the weight of the measure from the gross weight. The weight per cubic foot shall be calculated by multiplying the net weight by the factor for the measure used, determined as described in Section 3.

6.2 Volume of Concrete. The volume of concrete produced per batch shall be calculated as follows:

$$S = \frac{(N \times 94) + W_f + W_c + W_w}{W}$$

where:

S = volume of concrete produced per batch, in cubic feet,
N = number of bags of cement in the batch,
94 = net weight of a bag of cement, in pounds
W_f = total weight of fine aggregate in batch in condition used, in pounds,
W_c = total weight of coarse aggregate in batch in condition used, in pounds,
W_w = total weight of mixing water added to batch, in pounds, and
W = weight of concrete, in pounds per cubic foot.

6.3 Yield. The yield shall be calculated as follows:

$$Y = \frac{S}{N}$$

where:

Y = yield of concrete produced per 94 pound bag of cement, in cubic feet,
S = volume of concrete produced per batch, in cubic feet, and
N = number of bags of cement in the batch.

6.4 Relative Yield. Relative yield is the ratio of actual volume of concrete obtained to the volume as designed for the batch and shall be calculated as follows:

$$R_y = \frac{S}{V_d \times 27}$$

where:

R_y = relative yield,
S = volume of concrete produced per batch in cubic feet, and
V_d = volume of concrete which the batch was designed to produce in cubic yards.

NOTE–A value for R_y greater than 1.00 indicates an excess of concrete being produced whereas a value less than this indicates the batch to be 'short' of its designed volume.

6.5 Cement Factor. The "actual" cement factor shall be calculated as follows:

$$N_1 = \frac{27}{Y} \text{ or } N_1 = \frac{27N}{S}$$

N_1 = number of bags of cement per cubic yard of concrete produced (actual cement factor),
Y = yield of concrete produced per 94 pound bag of cement, in cubic feet,
N = number of bags of cement in the batch, and
S = volume of concrete produced per batch, in cubic feet.

6.6 Air Content. The air content shall be calculated as follows:

$$A = \frac{T - W}{T} \times 100$$

or by the formula

$$A = \frac{S - V}{S} \times 100$$

where:

A = air content (percentage of voids) in the concrete,
T = theoretical weight of the concrete, in pounds per cubic foot, computed on an air-free basis (Note),
W = weight of concrete, in pounds per cubic foot,
S = volume of concrete produced per batch, in cubic feet, and
V = total absolute volume of the component ingredients in the batch, in cubic feet.

NOTE–When the same materials and proportions are used to prepare different batches of concrete, it is assumed that the theoretical, air-free, weight per cubic foot of the concrete is constant for all batches. It is calculated from the formula:

$$T = \frac{W_1}{V}$$

where:

T = theoretical weight of the concrete, in pounds per cubic foot, computed on an air-free basis,
W_1 = total weight of the component ingredients in the batch, in pounds, and
V = total absolute volume of the component ingredients in the batch, in cubic feet.

The absolute volume of each ingredients is equal to the quotient of the weight of that ingredient divided by the product of its specific gravity times 62.4. For the aggregate components, the bulk specific gravity and weight should be based on the saturated, surface-dry condition. For the cement, a value of 3.15 may be used unless the actual specific gravity is determined by the Standard Method of Test for Specific Gravity of Hydraulic Cement (AASHO Designation: T-133).

7. References

AASHO T-121-
ASTM C-138-

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test No. 614
April 1974
4 Pages

Bureau of Materials, Testing & Research

Method of Test for

MEASURING LENGTH OF DRILLED CONCRETE CORES

1. Scope

1.1 This method covers the procedure for determining the length of a core drilled from a concrete structure, particularly from a concrete pavement, and is in accordance with AASHTO T 148.

2. Apparatus

2.1 The apparatus shall be a calipering device that will measure the length of axial elements of the core. While the details of the mechanical design are not prescribed, the apparatus shall conform to the requirements of Paragraphs 2.2 to 2.6.

2.2 The apparatus shall be so designed that the specimen will be held with its axis in a vertical position by three symmetrically placed supports bearing against the lower end. These supports shall be short posts or studs of hardened steel, and the ends that bear against the surface of the specimen shall be rounded to a radius of not less than ¼ in. and not more than ½ in.

2.3 The apparatus shall provide for the accommodation of specimens of different nominal lengths over a range of at least 4 to 11 in.

2.4 The calipering apparatus shall be so designed that it will be possible to make a length measurement at the center of the upper end of the specimen and at eight additional points spaced at equal intervals along the circumference of a circle whose center point coincides with that of the end area of the specimen and whose radius is three-fourths of the radius of the specimen.

2.5 The measuring rod or other device that makes contact with the end surface of the specimen for measurement shall be rounded to a radius of 1/8 inch. The scale on which the length readings are made shall be marked with clear, definite, accurately spaced graduations. Major graduations shall be 0.10 inch with minor graduations at each 0.02 inch.

2.6 The apparatus shall be stable and sufficiently rigid to maintain its shape and alignment without a distortion or deflection of more than 0.01 in. during all normal measuring operations.

3. Test Specimens

3.1 Cores used as specimens for length measurement shall be in every way representative of the concrete in the structure from which they are removed. The specimen shall be drilled with the axis normal to the surface of the structure, and the ends shall be free from all conditions not typical of the surfaces of the structure. Cores that show abnormal defects or that have been damaged appreciably in the drilling operation shall not be used. The core specimens for payment purposes shall be nominally 6 in. in diameter.

4. Procedure

4.1 Before any measurements of the core length are made, the apparatus shall be calibrated with suitable gauges so that errors caused by mechanical imperfections in the apparatus are known. When these errors exceed 0.01 in., suitable corrections shall be applied to the core length measurements.

4.2 The specimen shall be placed in the measuring apparatus with the smooth end of the core, that is, the end that represents the upper surface of a pavement slab or a formed surface in the case of other structures, placed down so as to bear against the three hardened-steel supports. The specimen shall be so placed on the supports that the central measuring position of the measuring apparatus is directly over the mid-point of the upper end of the specimen.

4.3 Nine measurements of the length shall be made on each specimen, one at the central position and one each at the eight additional positions described in Section 2.4. Each of the nine measurements shall be read directly to the nearest 0.02 inch.

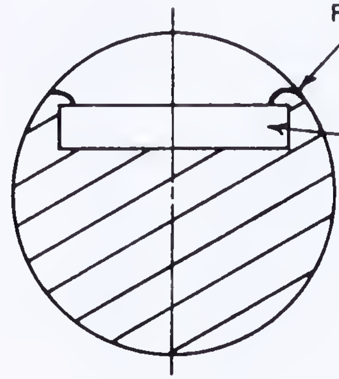
NOTE 1: If, in the course of the measuring operation, it is determined that the individual measurements vary by 0.2 of an inch, or more from the average, the specimen shall be rotated slightly about its axis and another complete set of measurements made. The average of the two sets of readings shall be recorded.

5. Report

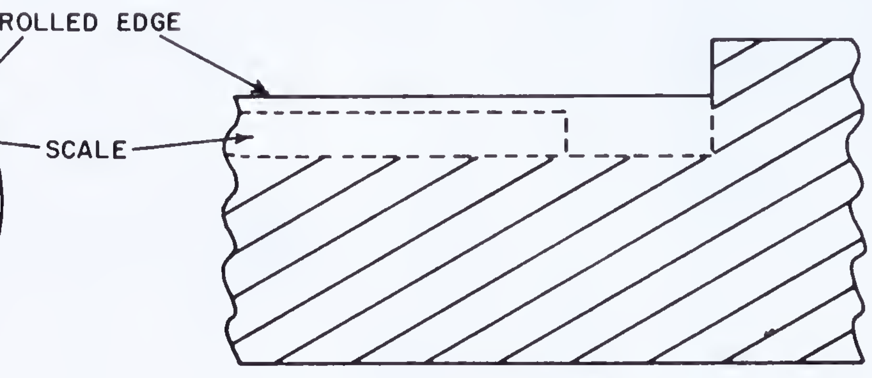
5.1 The individual observations shall be recorded to the nearest 0.02 inch and the average of the nine measurements expressed to the nearest 0.01 inch shall be reported as the length of the concrete core.

6. Reference

AASHTO T 148
ASTM C-174



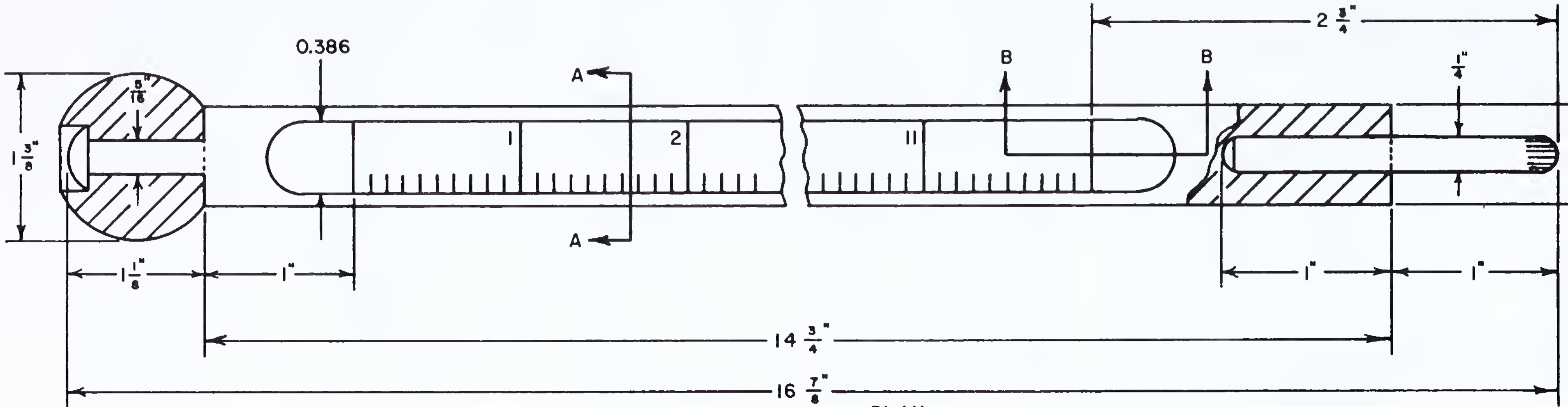
SECTION A-A



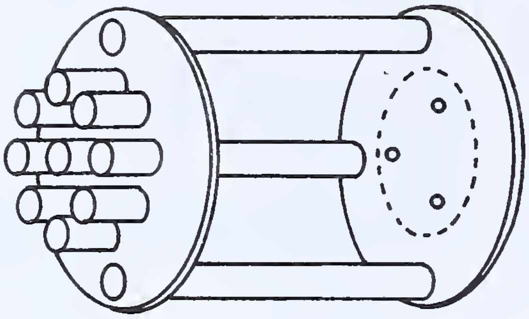
SIDE VIEW
DETAIL
B-B

CONVERSION TABLE

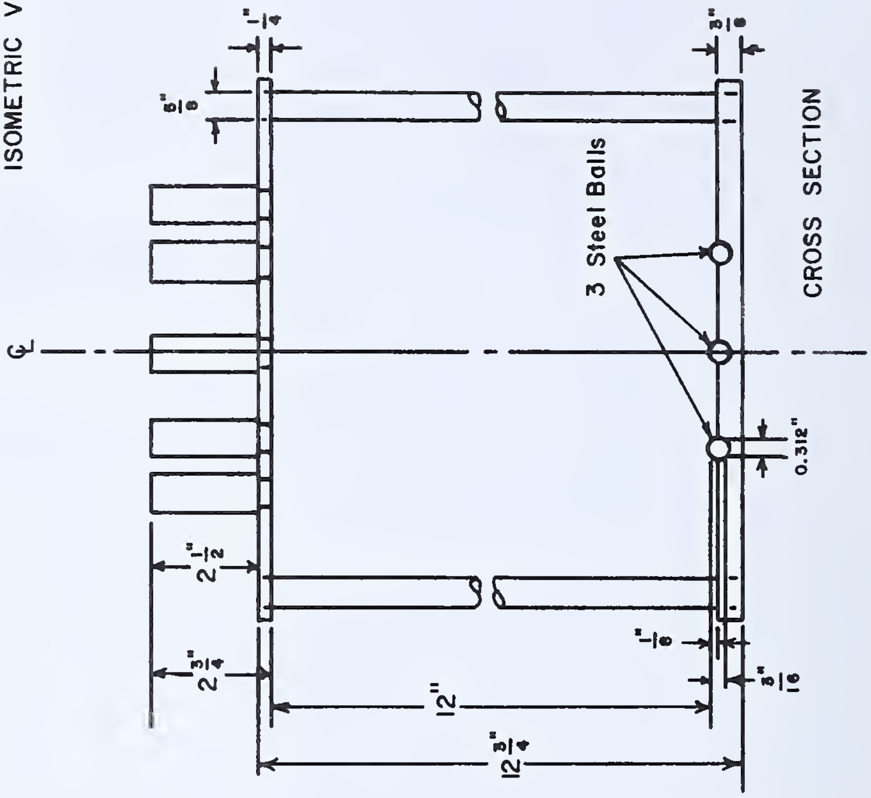
1/8"	= 3.2mm	1-3/8"	= 34.9mm
3/16"	= 4.8mm	2"	= 50.8mm
1/4"	= 6.4mm	2-1/4"	= 57.2mm
5/16"	= 7.9mm	2-1/2"	= 63.5mm
3/8"	= 9.5mm	2-3/4"	= 69.8mm
1/2"	= 12.7mm	6"	= 152.4mm
5/8"	= 15.9mm	10"	= 254.0mm
3/4"	= 19.0mm	12"	= 304.8mm
1"	= 25.4mm	12-3/4"	= 323.8mm
1-1/8"	= 28.6mm	14-3/4"	= 374.6mm
		16-7/8"	= 428.6mm



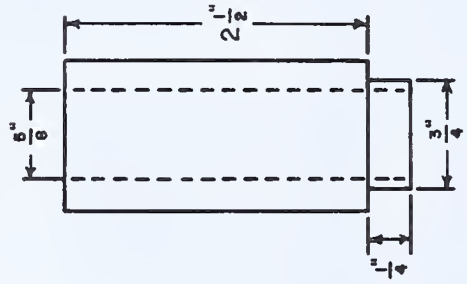
PLAN



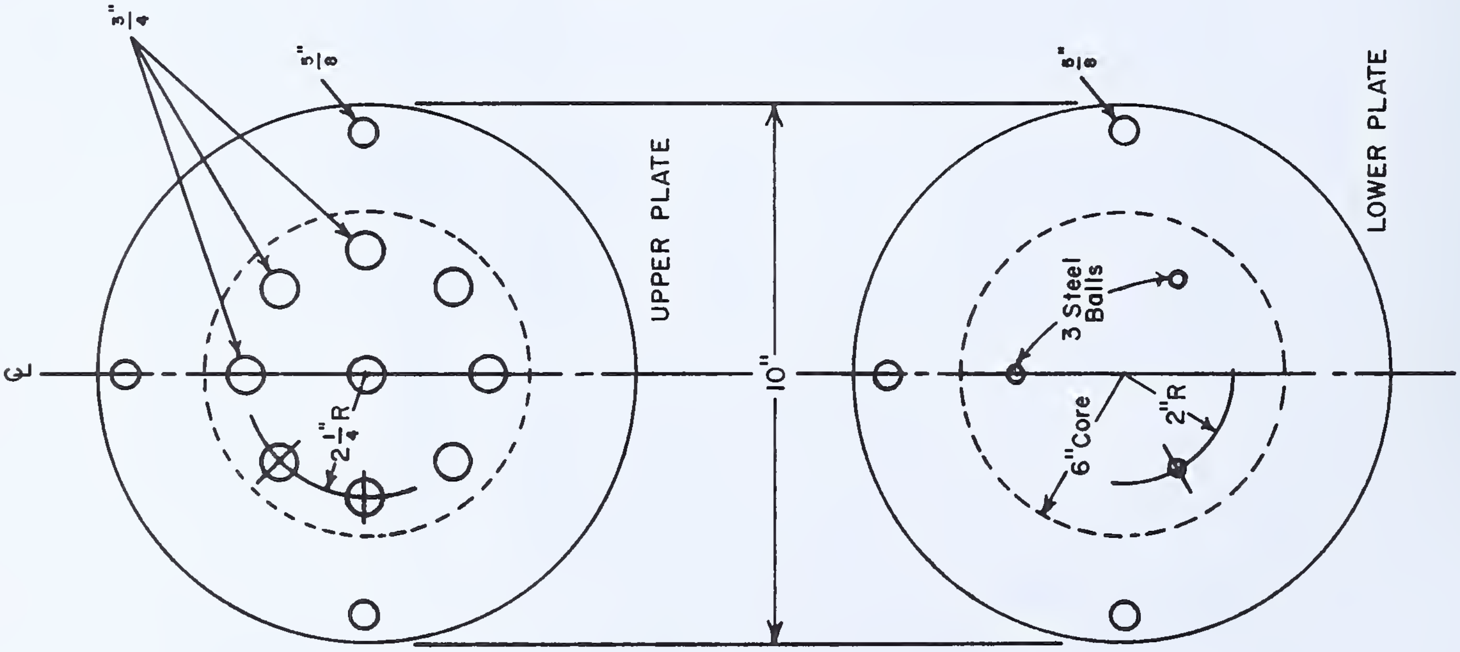
ISOMETRIC VIEW



CROSS SECTION



DETAIL OF GUIDE



Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 615
March 1972
5 Pages

Bureau of Materials, Testing & Research

Method of Test for

AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE PRESSURE METHOD

1. Scope

1.1 This method of test covers the determination of the air content of freshly mixed concrete from observations of the change in volume with a change in pressure. Detailed procedures are included for four types of apparatus. Apparatus of other designs has been developed and appropriate procedures have been prepared for use with such apparatus. This procedure is a modification of AASHO T 152-

NOTE 1. This method is intended for use with concretes and mortars made with relatively dense natural aggregates. It is not recommended for use on concretes made with lightweight aggregates, air—cooled blast furnace slag, or aggregates of high porosity. Air content of concrete containing slag or lightweight aggregates shall be determined by PTM 612.

2. Apparatus

2.1 All types of apparatus employed in determining the air content of freshly mixed concrete by the pressure method must, in order to provide satisfactory results, incorporate the following:

2.1.1 A measuring bowl of sufficiently rigid construction to make a pressure tight container of accurate volume and suitable to hold a representive sample of concrete to be tested.

2.1.2 A cover designed to be attached to the measuring bowl so as to make an adequately rigid, pressure tight assembly.

2.1.3 Facilities for applying a known pressure to the system and observing its effect on the volume of the sample.

2.1.4 Appropriate tools for placing and consolidating the sample and using the apparatus.

2.2 One satisfactory set of apparatus is described below:

2.2.1 Measuring Bowl. The measuring bowl shall be flanged cylindrical bowl, preferably of steel or other hard metal not readily attacked by the cement paste, having a diameter equal to 0.75 to 1.25 times the height. The outer rim and upper surface of the flange as well as the interior surfaces of the bowl, shall be smooth machined surfaces. The capacity of the measuring bowl shall be a minimum of 0.25 cu. ft. The measuring bowl and cover assembly shall be pressure tight and rigid.

NOTE 2. Larger containers should be used for larger samples of concrete in order to reduce errors of sampling.

2.3 Cover Assembly. The cover shall be flanged, preferably composed of steel or other hard metal not readily attacked by the cement paste. The outer rim and lower surface of the flange shall be such that the cover and the measuring bowl can be fitted together into a pressure tight assembly.

2.3.1 The cover shall be fitted with an approved gage. The graduations for a suitable range in air content shall be in percent and tenths of a percent as determined by the proper air pressure calibration test. The applied air pressure shall be indicated by a pressure gage connected to the air chamber. The gage shall have suitable graduations and a full scale reading twice the normal working pressure. The cover shall be fitted with a suitable device for venting of the air chamber, an air valve, and a petcock for bleeding off water as required. Suitable means for clamping the cover to the bowl shall be provided to make a pressure–tight seal without entrapping air at the joint between the flanges of the cover and bowl. A suitable hand pump shall be provided with the cover, either as an attachment or as an accessory. (Note 3).

NOTE 3. Pressures of 7.5 to 30 psi have been used satisfactorily. However, each container shall be calibrated for a stated normal working pressure.

2.4 Calibration Cylinder. The calibration cylinder shall consist of a cylindrical measure having an internal volume equal to approximately 3 to 6 percent of the volume of the measuring bowl.

2.5 A coil spring or other means shall be provided for holding the calibration cylinder in place.

2.6 A tube of appropriate diameter shall be provided either as an integral part of the cover assembly or separately so constructed that when water is added to the container, there will be a minimum of disturbance to the concrete.

2.7 A trowel of the standard brick mason's type shall be provided.

2.8 Tamping Rod. A round, straight, steel rod 5/8 in. in diameter and approximately 24 in. in length having the tamping end rounded to a hemispherical tip whose diameter is 5/8 in.

2.9 A mallet with a rubber or rawhide head, weighing 1/2 lb. for containers smaller than 0.50 cu. ft. capacity and 1 lb. or more for larger containers, shall be provided.

2.10 A strike–off bar consisting of a flat, straight, steel bar shall be provided.

2.11 A funnel with spout fitting into the tube described in Paragraph 2.6 shall be provided.

2.12 A measure having a 1/2 of 1 gallon capacity.

3. Procedure for determing Air Content of Concrete.

3.1 Specific directions for operation of the "ACME", "WASHINGTON", "PRESS-UR-METER", and "FACT" air meters are included in appendix I-III. For other types of air meters refer to manufacturer's instructions.

4. Calibration.

4.1 Specific directions for calibration of the "ACME", "WASHINGTON", "PRESS-UR-METER", and "FACT" air meters are included in appendix I-III. For other types of air meters refer to manufacturer's instructions.

5. References.

AASHO T 152-
ASTM C 231-

APPENDIX I

OPERATION AND CALIBRATION OF THE "PRESS–UR–METER" AND "WASHINGTON" AIR METERS

1. Operation

1.1 Fill the base with a sample of fresh concrete in three equal layers, rodding each 25 times with a 5/8 in. hemispherically–pointed rod. Tap the container 15 times with the rubber mallet after each layer.

1.2 Strike off the excess concrete by using a straight edge in a sawing motion. Wipe the flanges clean to ensure a tight seal with the cover.

1.3 Clamp the cover on with petcocks open.

1.4 Using the rubber syringe, supplied with each meter, inject water through one petcock until all air is expelled through the opposite petcock. Leave the petcocks open.

1.5 With built–in pump, pump air to "initial pressure" line gage.

1.6 Wait a few seconds and stabilize hand on dial at "initial pressure" by pumping up or bleeding with the needle valve, whichever is necessary.

1.7 Close both petcocks and press down on "thumb lever" to release the air into the base. Hold the thumb lever down for a few seconds, lightly tapping the gage with the finger, to stabilize the hand dial. Read percent of air on the dial.

1.8 Open petcocks to release pressure, remove cover and clean apparatus thoroughly.

2. Calibration

2.1 Fill the base completely full of water.

2.2 Perform operations 1.3 thru 1.7. The gage should read 0 percent air. If two or three trials show a uniform variation from 0 percent, change the initial pressure line to compensate for this variation.

2.3 Use one petcock as a control valve to fill the calibration cylinder.

2.4 Release the air at opposite petcock. Open both petcocks and let the water run back into the base. There is now 5 percent air in the base, (Note 4).

2.5 Perform operations 1.4 thru 1.7. The gage should read 5 percent of air.

NOTE 4. If a calibration cylinder is supplied with the air meter that represents some other percentage of the volume than 5 percent, substitute that percentage in 2.4 and 2.5 above.

APPENDIX II

OPERATION AND CALIBRATION OF THE "ACME" TYPE AIR METER

1. Operation

1.1 Fill the base with a sample of fresh concrete in three equal layers, rodding each 25 times with a 5/8 in. hemispherically—pointed rod. Tap the container 15 times with the rubber mallet after each layer.

1.2 Strike off the excess concrete by using a straight edge in a sawing motion. Wipe the flanges clean to ensure a tight seal with the cover, clamp cover on.

1.3 Close the petcock at the bottom of the water glass and open the petcock and funnel valve at the top. Fill the apparatus with water to a level slightly above the arrow mark on the graduated scale. Close the funnel valve and adjust the water level to the arrow mark on the graduated scale by means of the lower petcock.

1.4 Close the petcock and apply pressure with the pump until the gage reads exactly 15 lbs. per square inch.

1.5 Read the subsidence of the water level. The resulting value is the percentage of air in the concrete.

1.6 Release the pressure by opening the top petcock. Release the water by opening the C clamps. Remove the top and clean the apparatus at once and permit it to dry. It may be necessary to clean the water glass occasionally which, after removing the valve from the funnel valve assembly, may be done with a strip of cloth and one of the wire guards of the water glass. The threads on the thumb screws and on the funnel valve should be oiled occasionally.

2. Corrective Air-pressure to be used for Air Contents Exceeding Limits of Scale.

2.1 Correction multiples to be used for the "ACME" air meter when the air content of the concrete is so great that a reading is not obtainable using 15 lbs. pressure. Other types of air meters usually read higher air contents directly.

5 lb. = reading x 2.03
10 lb. = reading x 1.25
15 lb. = reading x 1.00

3. Calibration

3.1 Be sure that the calibration cylinder and the air meter have the same number. As the volumes of the air meters vary slightly, they must be individually calibrated and only their corresponding calibration cylinders may be used for this purpose.

3.2 Place the calibration cylinder in the air meter pot with the open end down. Fill the container with water. Clamp on the top of the air meter and fill the glass with water to the arrow mark. Apply 15 psi pressure. The scale reading on the water glass gage should be equal to the reading stamped on the bottom of the calibration cylinder, plus or minus 0.1 percent.

APPENDIX III

OPERATION AND CALIBRATION OF THE "FACT" AIR METER

1. Operation

1.1 Fill the base with a sample of fresh concrete in three equal layers, rodding each 25 times with a 5/8 in. hemispherically–pointed rod. Tap the container 15 times with the rubber mallet after each layer.

1.2 Strike off the excess concrete by using a straight edge in a sawing motion. Wipe the flanges clean to ensure a tight seal with the cover, and clamp the cover on with both petcocks open (petcock handles in up position).

1.3 Inject water through the No. 1 petcock (here after the No. 1 petcock is to the right when the apparatus is placed with the face of the gage toward the operator) until all air is expelled through the opposite petcock (No. 2).

1.4 Pump air to just a bit under the initial pressure point as shown on gage using built-in pump.

1.5 Wait a few seconds and stabilize the hand on the dial at "initial pressure" by pumping up direct to initial pressure reading. If you pump past the initial pressure reading, bleed off air by opening pump cap.

1.6 Close petcock No. 1 and immediately close petcock No. 2. Tap gage lightly with fingers and read percent of air in concrete directly on gage.

1.7 Release pressure from container by opening both petcocks, before unclamping and removing cover.

2. Calibration

2.1 Fill the base completely full of water and connect the accessory tubing to the underside of No. 1 petcock.

2.2 Perform operations 1.3 thru 1.6. The gage should read 0 percent air. If two or three trials show a unform variation from 0 percent, change the initial pressure line to compensate for this variation.

2.3 Screw the curved tube into the upper end of No. 1 petcock. Pump the air chamber up to the initial pressure. Close both petcocks, then use No. 1 petcock as a control valve to fill the calibration vessel.

2.4 Release the air at petcock No. 2. Open No. 1 petcock and let the water in the curved tube run back into the base. There is now 5 percent air in the base.

2.5 Perform operations 1.3 thru 1.6. The gage should read 5 percent of air.

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Pa. Test Method No. 616
March 1973
2 Pages

Bureau of Materials Testing & Research

Method of Test for

SIEVE ANALYSIS OF COARSE AND FINE AGGREGATE

1. Scope

1.1 This method of test which is a modification of AASHO T 27, covers a procedure for determining the particle size distribution of fine and coarse aggregates. This method is not intended for use in the analysis of aggregates recovered from bituminous mixtures or mineral fillers. Long-graded aggregates, such as Penna. No. 2A, which have substantial portions retained on and passing the No. 4 sieve, require a split gradation and shall be tested in accordance with PTM 619.

2. Apparatus

2.1 Balance. The balance or scale shall be accurate to not less than 0.1 percent of the sample weight.

2.2 Sieves. PTM 117. Mechanical sieve shakers of an approved type should be used. Hand sieving will be permitted only for emergency.

2.3 Timers. Electric or mechanical timers shall be accurate and variable in 1 minute increments with a minimum range of 15 minutes.

2.4 Oven. The oven shall be capable of maintaining a uniform temperature of 110 ± 5 C (230 ± 9 F).

NOTE: Hot plates may be used when test results must be obtained quickly. Confirmation samples should be tested using ovens as described above.

3. Samples

3.1 Samples shall first be subjected to the Method of Test for Material Finer Than the No. 100 or No. 200 Sieve in Aggregate, PTM 100. This procedure may be omitted provided the total amount of material finer than the No. 100 or No. 200 is not required and provided the accuracy requirements for the analysis do not require washing of the particles.

NOTE: When an accurate determination of the particle size distribution of a fine aggregate is required, the test portion of the sample shall first be tested in accordance with PTM 100.

3.2 A representative sample sufficient to yield not less than the appropriate weight of dried material, as shown below, shall be selected in accordance with PTM 625. The selection of samples of an exact predetermined weight shall not be attempted.

3.3 After drying, sample fractions of fine aggregate shall have an approximate weight as follows:

Material with a minimum of 95 per cent passing No. 8 sieve	100 g
Material with a minimum of 90 per cent passing No. 4 sieve and more than 5 per cent retained on a No. 8 sieve	500 g

NOTE: In no case, however, shall the fraction retained on any sieve at the completion of the sieving operation weigh more than 200 g. for the usual 8 in. diameter sieve. The amount of material retained on the critical sieve may be regulated by: (1) the introduction of a larger sieve immediately above the critical sieve or (2) by the selection of a sample of proper size.

3.4 After drying, samples of coarse aggregate shall have a minimum weight as follows:

Penna. Size	Minimum Wt. Lbs.
1B	10.0
2,1NS	26
2B, 2NS	35
3NS	44
3A	55
4	150

NOTE: Samples failing to meet the weight requirements of Sections 3.2 and 3.3 shall be deemed to be insufficient to produce reliable results. Only those samples containing sufficient material (not less than specified) shall be tested.

4. Procedure

4.1 Coarse aggregate samples may be air or oven dried.

4.2 Fine aggregate shall be oven-dried or dried on a hot plate with care to substantially constant weight at a temperature not exceeding 239 F.

4.3 Weigh the original sample and record (Note 1).

NOTE 1. Never place hot material on a scale or balance. If the sample is too hot to handle, it is too hot to weigh accurately.

4.4 The sample shall be separated into a series of sizes necessary to determine compliance with the specifications for the material under test. To reduce the possibility of overloading a sieve, an extra sieve having larger openings than the critical sieve may be introduced (Section 3.3) The sieving operation shall be conducted by means of a lateral and vertical motion of the sieve, accompanied by jarring action to keep the sample moving continuously over the surface of the sieve. In no case shall fragments in the sample be turned or manipulated through the sieve by hand. Mechanical sieving shall be controlled by a timer (Section 2.3) and shall continue for the predetermined time. The predetermined time is established when not more than 1 per cent by weight of the residue of coarse aggregate or 0.5 percent of the fine aggregate passes any sieve during 1 minute of sieving (Note 2). On that portion of the sample retained on No. 4 sieve, the above procedure for determining thoroughness of sieving shall be carried out with a single layer of material. Hand method of sieving shall be used to evaluate the thoroughness of mechanical sieving.

NOTE 2. Department experience shows that 5 minutes on a Gilson type shaker satisfies requirements for less than 1.0% passing per minute for most coarse aggregates. Penna. No. 4 and Penna. No. 3A material each require 9 minutes on a Gilson type shaker. Fine aggregate for use in portland cement concrete requires 8 minutes of shaking on a mechanical sieve shaker. Penna. No. 1 screenings and fine aggregate for use in bituminous concrete each require 12 minutes of mechanical shaking to satisfy these requirements.

4.5 The weight of each size material shall be determined on a scale or balance conforming to the requirements of Section 2.1. The weight of each size shall be obtained by weighing the pan material and accumulating the weight of each increasing sieve size.

4.6 If the accumulated weight after sieving differs from the original sample weight by more than 0.5 per cent, the results will be deemed unreliable and another sample will be tested.

5. Calculations

5.1 The percentage passing the given sieves shall be calculated by dividing the accumulated weights of each sieve by the total weight of sample as follows:

Given: Penna. Number 3A Stone, initial weight 62.3 lbs.

Sieve Size	Accumulative Wt. Passing	Total Per Cent Passing
2½	62.1	100
2	58.3	94
1½	35.4	57
1	8.1	13
½	1.8	3

6. Report

6.1 The results of the sieve analysis shall be reported as the total per cent passing each sieve. Percentages shall be reported to the nearest whole number.

7. Reference AASHO T 27

End of Text PTM 616

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 617
July 1971
1 Page

Bureau of Materials, Testing & Research

Method of Test for

SOLIDS IN AGGREGATE FOR CONCRETE

1. Scope

1.1 This method of test outlines the procedure for determining per cent solids in bulk volumes of aggregate, and is modified from AASHO T 20.

2. Percentage of Solids

2.1 The solids in aggregate shall be determined by the following formula:

$$\text{Percentage of solids} = \frac{\text{weight}}{\text{sp. gr.} \times 62.355} \times 100$$

where:

sp. gr. = the bulk specific gravity of the aggregate as determined by the appropriate method referred to in Section 3.1 or 3.2.

62.355 = the weight in pounds of 1 cu. ft. of water at the standard temperature of 16.7 C (62 F), and

Weight = the weight in pounds per cubic foot of the aggregate as determined by the method referred to in Section 3.3.

NOTE 1 – For complete accuracy, "weight" should be the weight of the air-dried sample minus the weight of any contained moisture.

3. Methods of Testing

The specific gravity and weight of the aggregate shall be determined in accordance with the following methods of test:

3.1 Specific Gravity of Fine Aggregate. See Method of Test for Specific Gravity and Absorption of Fine Aggregate, (PTM 505), Section 6.

3.2 Specific Gravity of Coarse Aggregate. See Method of Test for Specific Gravity and Absorption of Coarse Aggregate (PTM 506), Section 6.

3.3 Weight of Aggregate. Standard Method of Test for Unit Weight of Aggregate PTM 609.

4. Reference

AASHO T20
ASTM C30

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 619
September, 1973
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

SIEVE ANALYSIS OF LONG-GRADED AGGREGATE

1. Scope

1.1 This method of test, which is a modification of AASHO T 27, covers a procedure for determining particle size distribution of fine and coarse aggregates where substantial portions are retained on and pass the #4 sieve, making a split gradation necessary. This method is not intended for use in the analysis of aggregates recovered from bituminous mixtures or mineral fillers.

2. Apparatus

2.1 Balance — The balance or scale shall be accurate to not less than 0.1 percent of the sample weight.

2.2 Sieves — Refer to PTM 117.

2.3 Timers — Electric or mechanical timers shall be accurate and variable in 1 minute increments with a minimum range of 15 minutes.

2.4 Oven — The oven shall be capable of maintaining a uniform temperature of 110 ± 5 C (230 ± 9 F).

2.5 Shakers — Mechanical sieve shakers of an approved type should be used. Hand sieving will be permitted only for emergency.

NOTE: Hot plates may be used when test results must be obtained quickly. Confirmation samples should be tested using ovens as described above.

3. Samples

3.1 Visually examine the sample prior to conducting the test for sieve analysis. When the amount of silt and/or clay is present in such quantities as to become obvious that the specification limits will be approached, first subject the sample to PTM 100 using the No. 200 sieve.

3.2 If the sample submitted for test weighs less than 50 lbs., test the entire sample. If the sample submitted is larger than 50 pounds, reduce in size to not less than 40 lb. in accordance with PTM 625.

NOTE: The selection of a sample of an exact predetermined weight shall not be attempted.

4. Procedure

As this type of material consists of a mixture of both coarse and fine particles it is necessary to perform a split gradation. The analysis of the coarse portion is determined on the total test sample and that of the fine portion on a representative part of the fine portion which is later corrected to the total weight of the test sample.

4.1 Dry to constant weight, at a temperature of 110 ± 5 C (230 ± 9F) and record this weight to the nearest 0.1 lb.

NOTE: Never place hot material on a scale or balance. If the sample is too hot to handle, it is too hot to weigh accurately.

4.2 The sample shall be separated into a series of sieve sizes necessary to determine compliance with the specifications using extra sieves between the critical sieve sizes to prevent overloading. The total test sample shall be placed in a coarse aggregate sieve shaker until less than one percent of material passes each sieve per minute. A cumulative weight determination shall be made on each portion starting with the finest size, (material passing the No. 4 sieve). Retain the – #4 material separately for fine grading. Proceeding through the coarser sizes, the total percent passing each sieve shall be determined.

NOTE: Department experience shows that 5 minutes on a Gilson type shaker satisfies requirements for less than 1.0% passing per minute.

4.3 Reduce that portion passing the #4 sieve by means of a sample splitter or by quartering to yield a sample of approximately 500 grams. Break up clay, silt, or silt-clay lumps by use of a mortar and rubber-tipped pestle. Utilize care when reducing the minus #4 material to prevent any loss of fines. Weigh to the nearest 0.1 gram and record the weight for later calculations.

NOTE: The selection of samples of an exact predetermined weight shall not be attempted.

4.4 Place the resultant sample on a series of nested 8" diameter sieves containing those sieves required in the specifications using extra sieves between the critical sieve sizes to prevent overloading. Shake the sieves in a mechanical shaker until less than 0.5 percent passes each sieve per minute.

NOTE: Department experience shows that 12 minutes of shaking satisfies requirements for less than 0.5 percent passing each sieve per minute.

4.5 Starting with the finest fraction and proceeding through the coarser sizes, the size fractions are placed in the balance or scale pan. Each size fraction is added to the material already weighed. In this way, the total weight of the sample passing each sieve is read directly.

4.6 If the completed sample weight differs from the original starting weight by more than 0.5 percent the results are deemed unreliable and another sample will be tested.

5. Calculations

5.1 The percentage passing each sieve size is based on the weight of the entire sample tested.

5.2 The percentage passing the sieves used for the coarse portion shall be calculated by multiplying the individual corrected weights by the factor, "F", (reciprocal of the total weight), using the following formula:

$$C = (F \times B)\,100$$

Where:

C = Total percentage passing
B = Corrected weight of material passing each sieve = the cumulative weight on the sieve plus the weight of the minus #4 material.

$F = \text{Factor} = \frac{1}{A}$

A = Corrected weight of total sample used for sieve analysis (4.2).

5.3 The percentage passing each 8" diameter sieve shall be calculated by the following formula:

$$E = (K \times H) 100$$

Where:

E = Total percentage passing each 8" Diameter sieve

K = Factor $\frac{G}{D}$
H = Weight of material passing each 8" Diameter sieve
G = Percent passing #4 sieve (4.2)
D = Total corrected weight of sample used for fine gradation

6. Report

6.1 The results of the sieve analysis shall be reported as the total percent passing each sieve. Percentages shall be reported to the nearest whole number.

7. Reference

AASHO T 27

ASTM C 136

PTM 117

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 621
March 1973
2 Pages

Bureau of Materials, Testing & Research

Method of Test for
DETERMINING THE PERCENTAGE OF CRUSHED FRAGMENTS IN GRAVEL

1. Purpose and Scope

1.1 This method of test covers the procedure for determining the percentage of crushed fragments contained in a sample of crushed gravel.

1.2 The percentage of crushed fragments specified in Form 408 is the minimum amount considered necessary to provide adequate strength and stability in subbases and the required voids ratio in bituminous and portland cement concretes.

2. Sampling

2.1 Obtain the sample in accordance with PTM 607. (NOTE 1). Select a test portion of the sample in accordance with PTM 625 and of sufficient size to be not less than the weights specified in the following table. Do not select samples of an exact, predetermined weight.

Gradation	Approx.—Min. Weight	
	kg	lb
1B	0.5	1.0
2B, 2, INS	1.2	2.5
2A, 3A, 2NS	2.5	5.0

NOTE 1. It is recommended that the washed and dried aggregate resulting from the procedure of PTM 100. "Amount of Material Finer than No. 100 or No. 200 Sieve in Aggregate," be used.

3. Procedure

3.1 Separate the material on the #4 sieve. Discard all material passing the #4 sieve. (NOTE 2.)

NOTE 2. When determining the crush count of Pa. 3A material, separate on the ½-inch sieve and discard all material passing.

3.2 Determine to the nearest gram the weight of the crushed fragments in the sample obtained in Section 3.1 above. (NOTE 3.)

NOTE 3. A crushed fragment is one having one or more fractured faces. Nicked fragments will not be considered as crushed. A fractured face is a face that exposes the interior of the gravel particle.

4. Calculations

4.1 The percentage of crushed fragments shall be determined as follows:

$\frac{A}{B} \times 100$ = percent crushed

A = weight of crushed fragments

B = total weight of sample retained on the sieve, (Section 3.1).

5. Report

5.1 Report amount crushed to the nearest percent.

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Pa. Test Method No. 622
March 1973
3 Pages

Bureau of Materials, Testing & Research

Method of Test for
RESISTANCE TO ABRASION OF COARSE AGGREGATE BY USE OF THE LOS ANGELES MACHINE

1. Scope

1.1 This method which is a modification of AASHO T 96-68I covers a procedure for testing sizes of coarse aggregate smaller than 1½ in. for resistance to abrasion using the Los Angeles testing machine.

2. Apparatus

2.1 Los Angeles Machine — The Los Angeles abrasion testing machine, conforming in all its essential characteristics to the design shown in Fig. 1, shall be used. The machine shall consist of a hollow steel cylinder, closed at both ends, having an inside diameter of 28 ± 0.2 in. and an inside length of 20 ± 0.2 in. The cylinder shall be mounted on stub shafts attached to the ends of the cylinder but not entering it, and shall be mounted in such a manner that it may be rotated with the axis in a horizontal position. An opening in the cylinder shall be provided for the introduction of the test sample. A suitable, dust-tight cover shall be provided for the opening with means for securing the cover in place. The cover shall be so designed as to maintain the cylindrical contour of the interior surface unless the shelf is so located that the charge will not fall on the cover, or come in contact with it during the test. A removable steel shelf extending the full length of the cylinder and projecting inward 3.5 ± 0.1 in. shall be mounted on the interior cylindrical surface of the cylinder, or on the inside surface of the cover, in such a way that a plane centered between the large faces coincides with an axial plane (NOTE 1).

NOTE 1 — The shelf shall be of such thickness and so mounted, by bolts or other approved means, as to be firm and rigid. The position of the shelf shall be such that the distance from the shelf to the opening, measured along the outside circumference of the cylinder in the direction of rotation, shall be not less than 50 in. The use of a shelf of wear-resistant steel, rectangular in cross-section and mounted independently of the cover, is preferred. However, a shelf consisting of a section of rolled angle, properly mounted on the inside of the cover plate, may be used provided the direction of rotation is such that the charge will be caught on the outside face of the angle. If the shelf becomes distorted from its original shape to such an extent that the requirements given in A 1.2 of the Appendix to this method are not met, the shelf shall be either repaired or replaced before additional abrasion tests are made.

2.2 Sieves — conforming to the Specifications for Sieves for Testing Purposes (AASHO Designation: M 92).

2.3 Balance — The balance or scales shall be sensitive to within 0.1 percent of the weight of the sample to be tested.

2.4 Oven — The oven shall be capable of maintaining a temperature of 110 ± 5 C (230 ± 9 F).

3. Abrasive Charge

3.1 The abrasive charge shall consist of steel spheres averaging approximately 1 27/32 in. in diameter and each weighing between 390 and 445 g. (NOTE 2).

NOTE 2 — Steel ball bearings 1 13/16 in. and 1 7/8 in. in diameter, weighing approximately 400 and 440 g. each, respectively, are readily available. Steel spheres 1 27/32 in. in diameter, weighing approximately 420 g. may also be obtainable. The abrasive charge may consist of a mixture of these sizes conforming to the weight tolerances of 3.1 and 3.2.

3.2 The abrasive charge shall consist of eleven (11) spheres weighing 4584 ± 25 grams.

4. Test Sample

4.1 The test sample shall be prepared from aggregate representative of that being furnished. The aggregate shall be separated into individual size fractions, washed, oven-dried at 110 ± 5C (230 ± 9F) to substantially constant weight, and recombined to the grading of Table I. The weight of sample prior to the test shall be recorded to the nearest gram.

TABLE I – GRADING OF TEST SAMPLE

Sieve Size			Grading
Passing	Retained On		(grams)
3/4 in.	½ in.		2500 ± 10
½ in.	3/8 in.		2500 ± 10
		Total Sample Weight	5000 ± 10

4.2 For limited source approval, other gradings and abrasive charges in conformance with AASHO T96 may be used.

5. Procedure

5.1 The test sample and the abrasive charge shall be placed in the Los Angeles abrasion testing machine and the machine rotated at a speed of 30 to 33 RPM for 500 revolutions. The machine shall be so driven and so counterbalanced as to maintain a substantially uniform peripheral speed (NOTE 3). After the prescribed number of revolutions, the material shall be discharged from the machine and separation of the sample made on a No. 12 (1.68-mm) sieve in a manner conforming to Section 5 (b) of The Method of Test for Sieve Analysis of Coarse and Fine Aggregate (PTM 616). The material coarser than the No. 12 sieve shall be weighed to the nearest 1 g. If the percentage of wear is less than 2.0 percentage points under the maximum allowable for the type of aggregate tested, the material coarser than the No. 12 sieve shall be washed, oven-dried at 110 ± 5 C (230 ± 9 F) to substantially constant weight, and weighed to the nearest 1 g.

NOTE 3 – Back lash or slip in the driving mechanism is very likely to furnish test results which are not duplicated by other Los Angeles abrasion machines producing constant peripheral speed.

5.2 When the percentage of wear for any grading is within 3.0 percentage points of the maximum allowable for the type of aggregate tested, not less than 2 additional samples from the lot should be tested.

6. Calculation

6.1 The difference between the original weight and the final weight of the test sample shall be expressed as a percentage of the original weight of the test samples. This value shall be reported as the percentage of wear.

$$\%\ \text{Wear} = \frac{\text{Weight Loss}}{\text{Original Weight}} \times 100$$

6.2 Where more than one determination of percentage of wear is made on a lot, the average of the determinations will be reported.

7. Reference

AASHO T 96
ASTM C 131

APPENDIX

A 1. MAINTENANCE OF SHELF

A. 1.1 The shelf of the Los Angeles Machine is subject to severe surface wear and impact. With use, the working surface of the shelf is peened by the balls and tends to develop a ridge of metal parallel to and about 1¼ in. (32 mm) from the junction of the shelf and the inner surface of the cylinder. If the shelf is made from a section of rolled angle, not only may this ridge develop but the shelf itself may be bent longitudinally or transversely from its proper position.

A. 1.2 The shelf should be inspected periodically to determine that it is not bent either lengthwise or from its normal radial position with respect to the cylinder. If either condition is found, the shelf should be repaired or replaced before further abrasion tests are made. The influence on the test result of the ridge developed by peening of the working face of the shelf is not known. However, for uniform test conditions, it is recommended that the ridge be ground off if its height exceeds 0.1 in. (2 mm).

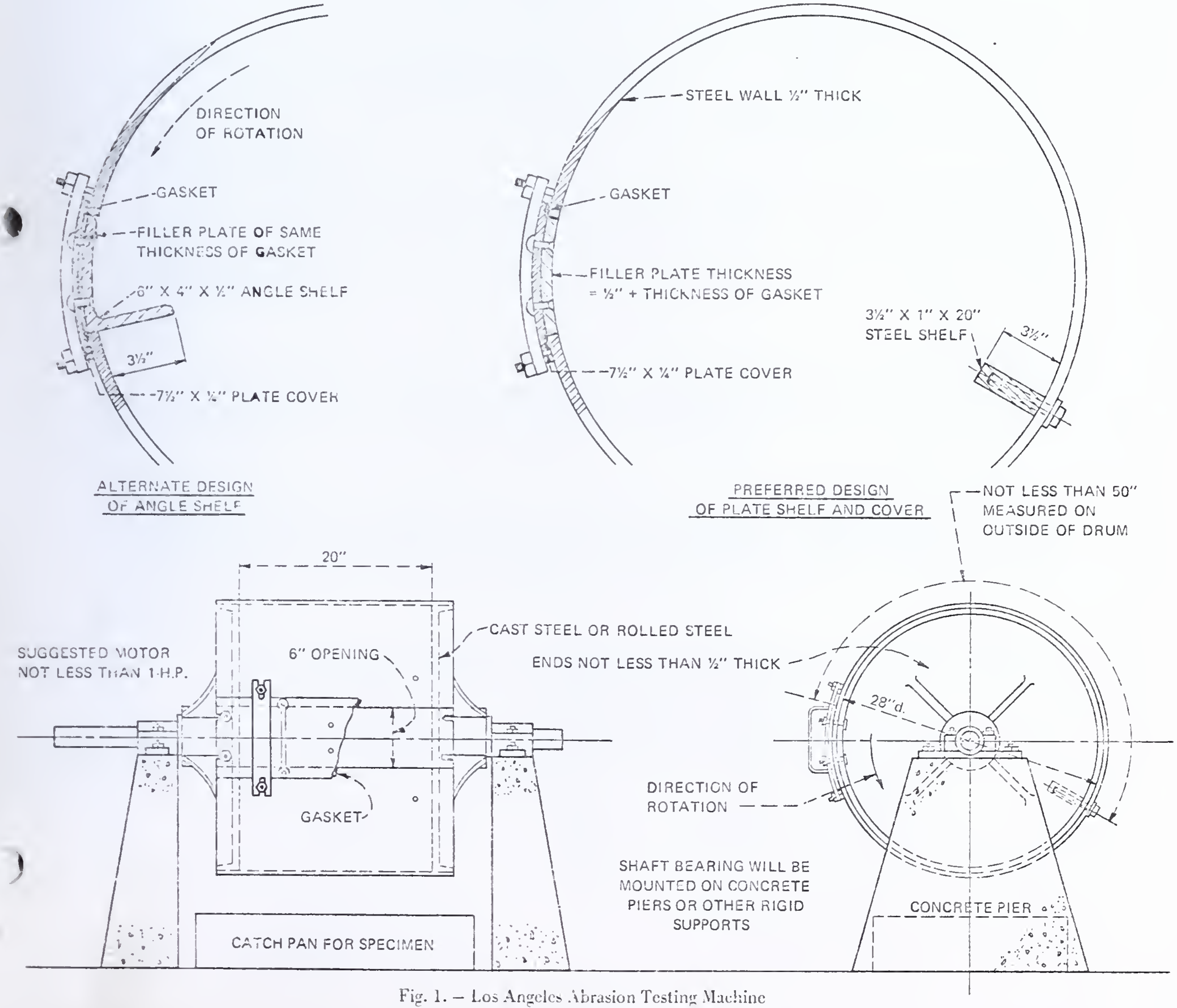
DIRECTION OF ROTATION
GASKET
FILLER PLATE OF SAME THICKNESS OF GASKET
6" X 4" X ½" ANGLE SHELF
3½"
7½" X ¼" PLATE COVER
ALTERNATE DESIGN OF ANGLE SHELF
STEEL WALL ½" THICK
GASKET
FILLER PLATE THICKNESS = ½" + THICKNESS OF GASKET
3½" X 1" X 20" STEEL SHELF
3½"
7½" X ¼" PLATE COVER
PREFERRED DESIGN OF PLATE SHELF AND COVER
NOT LESS THAN 50" MEASURED ON OUTSIDE OF DRUM
20"
SUGGESTED MOTOR NOT LESS THAN 1-H.P.
6" OPENING
CAST STEEL OR ROLLED STEEL ENDS NOT LESS THAN ½" THICK
28"d.
GASKET
DIRECTION OF ROTATION
SHAFT BEARING WILL BE MOUNTED ON CONCRETE PIERS OR OTHER RIGID SUPPORTS
CONCRETE PIER
CATCH PAN FOR SPECIMEN

Fig. 1. – Los Angeles Abrasion Testing Machine

Commonwealth of Pennsylvania
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March 1972
2 Pages

Bureau of Materials Testing & Research

Method of Test for

SIEVE ANALYSIS OF ANTI-SKID MATERIALS

1. Scope

1.1 This method of test covers a procedure for determining the particle size distribution of Anti-Skid Materials.

2. Apparatus

2.1 Balance – The balance or scale shall have a sensitivity of not less than 0.1 g.

2.2 Sieves – Standard 8" diameter, meeting the requirements of PTM 117. Mechanical sieve shakers of an approved type should be used. Hand sieving may be permitted.

2.3 Timers – Electric or mechanical timers shall be accurate and variable in 1 minute increments with a minimum range of 15-minutes.

2.4 Oven – The oven shall be capable of maintaining a uniform temperature of 110+ 5 C (230+ 9 F).

NOTE: Hot plates may be used when test results must be obtained quickly. Confirmation samples should be tested using ovens as described above.

3. Samples

3.1 Samples for sieve analysis shall be obtained from the materials submitted for test by the use of a sample splitter or by quartering. Type III Anti-Skid samples shall be thoroughly mixed and in a moist condition. The selection of samples of an exact predetermined weight shall not be attempted.

3.2 After drying, sample fractions of the anti-skid material shall have an approximate weight of 500 g.

NOTE: In no case, however, shall the fraction retained on any sieve at the completion of the sieving operation weigh more than 200 g. for the usual 8 in. diameter sieve. The amount of material retained on the critical sieve may be regulated by: (1) the introduction of a larger sieve, immediately above the critical sieve or (2) by the selection of a sample of proper size.

4. Procedure

4.1 The sample shall be oven-dried or dried on a hot plate with care to substantially constant weight at a temperature not exceeding 239 F and cooled to confortable handling temperature.

NOTE: Never place hot material on a scale or balance. If the sample is too hot to handle, it is too hot to weigh accurately.

4.2 The sample shall be separated into a series of sizes using such sieves as are necessary to determine compliance with the specifications for the material under test. To reduce the possibility of overloading a sieve, an extra sieve having larger openings than the critical sieve may be introduced (Section 3.2 Note). The sieving operation shall be conducted by means of a lateral and vertical mortion of the sieve, accompanied by jarring action to keep the sample moving continuously over the surface of the sieve. In no case shall fragments in the sample be turned or manipulated through the sieve by hand. Mechanical sieving shall be controlled by a timer (Section 2.3) and shall continue for the predetermined time. Department experience shows that Type I Anti-Skid Material requires 1.5 minutes of shaking on a mechanical shaker. Type II and Type III Anti-Skid Material each require 3 minutes of mechanical shaking.

4.3 The weight of each size material shall be determined on a scale or balance conforming to the requirements of Section 2.1. The weight of each size shall be obtained by weighing the pan material and accumulating the weight of each increasing sieve size. The weights shall be recorded to the nearest 0.1g.

5. Calculations

5.1 The percentage passing the given sieves shall be calculated by dividing the accumulated weights of each sieve size by the total weight of sample.

6. Report

6.1 The results of the sieve analysis shall be reported as the total per cent passing each sieve. Percentages shall be reported to the nearest whole number.

7. Reference

PTM 117

End of Test PTM 624

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 625
August 1973
3 Pages

Bureau of Materials, Testing & Research

METHODS FOR REDUCING FIELD SAMPLES OF AGGREGATE TO TESTING SIZE

1. Scope

1.1 These methods cover the reduction of field samples of aggregate to the appropriate size for testing, employing techniques that are intended to minimize variations in measured characteristics between the test samples so selected and the field sample. (NOTE 1).

NOTE 1 – Under certain circumstances, reduction in size of the field sample prior to testing is not recommended. Substantial differences between the selected test samples sometimes cannot be avoided, as for example, in the case of an aggregate having relatively few large size particles in the field sample. The laws of chance dictate that these few particles may be unequally distributed among the reduced size test samples. Similarly, if the test sample is being examined for certain contaminants occurring as a few discrete fragments in only small percentages, caution should be used in interpreting results from the reduced size test sample. Chance inclusion or exclusion of only one or two particles in the selected sample may importantly influence interpretation of the characteristics of the field sample. In these cases, the entire field sample should be tested.

2. Selection of Method

2.1 Fine Aggregates – a. Field samples of the fine aggregate that are drier than the saturated-surface-dry condition (Note 2) shall be reduced in size by a mechanical splitter according to Method A. b. Field samples of fine aggregates having free moisture on the particle surfaces may be reduced in size by quartering according to Method B, or by treatment as a miniature stockpile as described in Method C (the "thief" method). c. Field samples of fine aggregate having free moisture on particles surfaces may be reduced to testing size by drying the entire sample to at least the surface-dry condition, using temperatures that do not exceed those permitted for any of the tests contemplated, and then reduce to sample size by a mechanical splitter according to Method A.

2.1.1 If a moist field sample is very large, a preliminary split may be made using a mechanical splitter having wide chute openings (1½ in. (38 mm) or more) to reduce the sample to not less than 5000 g, the portion so obtained is then dried, and reduction to test sample size completed using Method A.

NOTE 2 – The method of determining the saturated-surface-dry condition is described in Section 3.1 of PTM 505. As a quick approximation, if the fine aggregate will retain its shape when molded in the hand, it may be considered to be wetter than saturated-surface-dry.

2.2 Coarse Aggregate – Use of a mechanical splitter in accordance with Method A is preferred; the field sample shall be reduced by quartering in accordance with Method B only when a mechanical splitter is not available.

3. Field Sample Size

3.1 When gradation tests only are contemplated, the size of the field sample shall conform to the requirements of PTM 616 or 619, whichever applies. When additional tests are to be conducted, the user shall satisfy himself that the initial size of the field sample is adequate to accomplish all intended tests.

METHOD A – MECHANICAL SPLITTER

4. Apparatus

4.1 Sample Splitter – Sample splitters shall have an even number of equal width chutes, but not less than a total of eight for coarse aggregate, or twelve for fine aggregate, which discharge alternately to each side of the splitter. The minimum width of the individual chute shall be approximately 50 percent larger that the largest particles in the sample to be split (Note 3). The splitter shall be equipped with two containers to hold the two halves of the sample following splitting. It shall also be equipped with a hopper or a straightedged pan which has a width equal to or slightly less than the overall width of the feed chute, by which the sample may be fed at a controlled rate of the openings. The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material (Fig. 1).

NOTE 3 – Mechanical splitters are commonly available in sizes adequate for coarse aggregate having the largest particle not over 1½ in. (37.5 mm). For fine aggregate, a splitter having chutes ½ in. (13 mm) wide will be satisfactory when the entire sample will pass a 3/8-in. (9.5 mm) sieve.

5. Procedure

5.1 Determine the number of passes required in the riffling operation from the total sample weight and the minimum allowable weight indicated in the appropriate PTM. Example: If the total sample weighs 80 lbs and a minimum weight of 35 lbs is required, one pass through the riffles will provide about 40 lbs. If the total sample weighs 50 lbs. and a minimum of 35 lbs is required, two passes through the splitters will provide about 37½ lbs. (25 plus 12½) On the other hand, the riffle splitter may be used in blending as well as to divide. If the total sample is composed of 4 bags each weighing about 80 lbs. and a test sample weight if 35 lbs is sufficient, three divisions of each bag will provide a combined sample weight of about 40 lbs.

5.2 Spread the material evenly in the container. When using a pan, do not dump the sample bag into the container but pour it back and forth and then spread it evenly. Raise the container, resting the front edge on the top of the material hopper, and slowly tilt it so that the material flows in a uniform stream through the hopper, into the slots, and then into the riffle pans, one half of the sample in each pan. Do not allow the material to build up in or above the riffle slots. If any material remains in the hopper or slots, shake or vibrate the riffle.

NOTE: One or two blows with a rubber mallet on the end of the frame is usually sufficient. Under no circumstances shovel the sample into the riffle or pour into the riffle from a narrow container or round scoop.

When a large sample splitter with a holding hopper is used, place the sample in the hopper in the same manner as described above for the pan-type container. The sample is then allowed to pass through the riffles by slowly opening the bottom of the hopper. The material should flow, not drop, through the riffles.

METHOD B – QUARTERING

6. Apparatus

6.1 Apparatus shall consist of a straightedged scoop, shovel or trowel and a broom or brush.

7. Procedure

7.1 Place the field sample on a hard clean, level surface where there will be neither loss of material nor the accidental addition of foreign material. Mix the material thoroughly by turning the entire sample over three times. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one. Carefully flatten the conical pile to a uniform thickness and diameter by pressing down the apex with a shovel so that each quarter sector of the resulting pile will contain the material originally in it. The diameter should be approximately four to eight times the thickness. Divide the flattened mass into four equal quarters with a shovel or trowel and remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean. Successively mix and quarter the remaining material until the sample is reduced to the desired size.

METHOD C – MINIATURE STOCKPILE SAMPLING

8. Apparatus

8.1 Apparatus shall consist of either a small sampling thief, small scoop, or spoon.

9. Procedure

9.1 Place the field sample on a hard, clean, level, non-absorbent surface. Thoroughly mix the sample and form a minature stockpile. Obtain sample for each test by selecting at least five increments of material at random locations from the miniature stockpile, using any of the devices described in 8.1.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 626
June, 1973
1 Page

Bureau of Materials, Testing and Research

Method of Test for
CALIBRATION OF OUTPUT METER ON MOBILE CONCRETE PLANTS

1. Purpose

1.1 This method provides a procedure for obtaining a correction factor to be applied to the output meter reading to determine the actual volume of concrete discharged.

2. Equipment

2.1 The required equipment is the same as that described by Section 2, PTM 613.

3. Procedure

3.1 Weigh the empty calibration measure and record the weight (Wm).
3.2 Record the output meter reading (R1).
3.3 Fill the calibration measure to approximately 90% of its capacity, taking care that the entire discharge enters the container.
3.4 Record the output meter reading (R2).
3.5 Weigh the measure containing the concrete and record the weight (Wt).
3.6 Determine the unit weight (Wu) of an additional sample of concrete in accordance with PTM 613.

4. Calculations

4.1 Calculate the metered volume of concrete (Vm) placed in the calibration measure by subtracting the first meter reading from the final reading.

$$Vm = R2 - R1$$

4.2 Calculate the actual weight of the concrete in the measure.

$$Wa = Wt - Wm$$

4.3 Calculate the actual volume (Va) of concrete in the calibration measure by dividing the actual weight of the concrete by the unit weight (W) determined from this same batch of concrete,

$$Va = \frac{Wa}{W}$$

4.4 Calculate the metering correction factor (K) by dividing the calculated, actual volume of concrete in the measure by the volume discharged as indicated by the output meter.

$$K = \frac{Va}{Vm}$$

NOTE 1 – This method can be used only in conjunction with PTM 613, Method of Test for Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete.

Reference: ASTM: C 685

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 627
July 1973
3 Pages

Bureau of Materials, Testing and Research

Test Method for
UNIFORMITY OF COMPOSITION OF FRESH PORTLAND CEMENT CONCRETE

1. Scope

1.1 This method provides a basis for evaluating the uniformity of composition of portland cement concrete while it is still in the plastic state. Application of this method may be found in investigations of effectiveness of mixing, or uniformity within a batch; reproducibility of proportions, or uniformity between batches; and accuracy of continuous proportioning, as in mobile concrete plants.

2. Equipment

2.1 The equipment shall conform to the requirements of PTM 613 or PTM 615.

3. Sample

3.1 Obtain the sample in accordance with PTM 601.

4. Procedure

4.1 Determine the gradations of the fine and coarse aggregates. (PTM 616)

4.2 Determine the weight per cubic foot in accordance with PTM 613 and the air content in accordance with PTM 612 or PTM 615, whichever applies.

4.3 Take a carefully determined ¼ cubic foot of concrete, then wash and dry in accordance with PTM 100.

NOTE: It is assumed that the bowl of a ¼ cubic foot capacity air meter will be used. A larger unit measure may be used.

4.4 Sieve the dry sample in accordance with PTM 616, except that the following sieves should be used: 3/4″, ½″, 3/8″, #4, to prevent overloading any screens.

4.5 Weigh and record the weight of the aggregate passing the No. 4 screen and the total weight retained on the No. 4 screen (WpM, WrM). These are referred to later as the measured weights.

5. Calculations

5.1 Calculate the expected weights of aggregate retained on the No. 4 screen and passing the No. 4 screen as follows:

5.1.1 From Form CS4220 obtain the saturated, surface-dry (SSD) weight of the coarse and fine aggregates per cubic yard of concrete. Divide each of these weights by 108 to determine the aggregate weights in one-quarter cubic foot.

NOTE: There are 108 quarter-cubic-feet in each cubic yard (108=4 x 27). If a unit measure larger than ¼ cubic foot capacity has been used in Section 4.3, above, the denominator must be changed accordingly.

5.1.2 From Bulletins 13 & 14 determine the percent absorption. Divide the weights calculated in Section 5.1.1 above by 1.00 plus the absorption expressed as a decimal.

5.1.3 From the gradations of the aggregates (See Section 4.1, above), determine the percent retained on and passing the No. 4 screen for both coarse and fine aggregate separately. Then multiply each of these four numbers by the corresponding SSD weights for a quarter cubic foot of concrete (which were calculated in Section 5.1.2) to determine the expected weights of coarse and fine aggregate retained on and passing the No. 4 screen.

5.1.4 Add together the expected weights of coarse and fine aggregates retained on the No. 4 screen, calculated above, to determine the total, expected weight of aggregate retained on the No. 4 screen (WrE). Similarly, determine the total expect weight of aggregate passing the No. 4 screen (WpE).

5.1.5 For the retained and passing portions separately, subtract the measured from the expected weight, divide the difference by the expected weight, then multiply by 100. In this way the percent deviation, plus or minus, from the expected is calculated.

For aggregate retained on the No. 4 screen:

$$\frac{WrE - WrM}{WrE} \times 100 = \%\ \text{Deviation}$$

For aggregate passing the No. 4 screen:

$$\frac{WpE - WpM}{WpE} \times 100 = \%\ \text{Deviation}$$

6. Report

6.1 The reported percent deviation for material retained on and passing the No. 4 screen shall be the average of two determinations of each.

Reference: ASTM C-685

The calculations of expected weights are summarized below:

LINE	COARSE AGG.	FINE AGG.
1. SSD Weights (Form CS 4220)	______	______
2. Divide Line 1 by 108	______	______
3. Percent Absorption	______	______
4. Line 2 $\div$ $(1.00 + \frac{\%\text{Abs}}{100})$	______	______
5. Percent retained on No. 4	______	______
6. Percent passing No. 4	______	______
7. Line 5 x Line 4	______	______
8. Line 6 x Line 4	______	______

9. Line 7 (CA) + Line 7 (FA) ______ = WrE

10. Line 8 (CA) + Line 8 (FA) ______ = WpE

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 628
January, 1975
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

DETERMINING FLOWABILITY OF GROUTING MATERIAL

1. Scope

1.1 This method of test covers the procedure for determining flow of grout material.

2. Apparatus

2.1 The apparatus for determining the flowability of grout shall consist of a cone shaped weight, a rod protruding from the weight, and a frame to guide the rod and serve as a reference for measuring the depth of penetration.

2.2 Weight—The weight shall be a cone approximately 2½ inches in diameter at the base and 2-7/8 inches high with a rod protruding from the base of the cone (see Figure 1 for futher details). The cone may be machined from metal stock or cast or spun provided the dimensions and weight with the rod meet the requirements and the finish is smooth.(NOTE: In order to meet the weight requirement, it may be best to machine a partially-hollow cone from aluminum stock and then fill the hollow part with molten lead until the weight is correct.)

2.2.1 The weight plus the rod shall weigh 500 ± 3 gm.

2.3 Rod—The rod shall be of metal, 1/8 to ¼ inch in diameter and 10 inches long, and shall be graduated in increments of ¼ inch. Each inch will be marked from the zero point on the frame. Due to the rod being thin, the inch markings may be color-coded rather than marked with numbers. (i.e.- a given color stands for zero inch, another color for one inch, etc.)

2.4 Frame—The frame shall be approximately 15½ inches high and shall be constructed so as to fit over a standard 6 x 12 inch test cylinder mold. The frame may be constructed of either metal or wood and may be either two-sided or three-sided. The top of the frame shall contain a hole about 3/8 inch in diameter through which the rod of the weight may pass.

2.5 Molds—The molds shall be 6 x 12 inch size conforming to the requirements of ASTM Designation: C 470, Tentative Specifications for molds for Forming Concrete Test Cylinders Vertically. Not less than 3 molds shall be available.

3. Sample

3.1 The grout will be obtained directly from the outlet hose of the slab-jacking pump and should be placed in the mold in two or three layers, rodding between layers.

4. Procedure

4.1 Operate the grout pump for about two minutes; then fill a 6 x 12 cylinder mold with grout. Strike off the surface even with the top of the mold with a straight-edge. Place the filled mold on a level surface and then place the frame of the penetration device over the mold, making sure to hold the weight off the surface of the grout. Carefully lower the tip of the cone-shaped weight until it just touches the surface of the grout. Release the weight smoothly letting go of the rod above the frame and allow the weight to sink into the grout. Read the depth of penetration by determing the rod gradation mark which lines up with the top of the frame. Take three readings per batch of grout using a new cylinder for each reading. Wash off the weight between readings.

5. Report

5.1 The penetration shall be recorded in terms of inches of penetration. The values reported shall be the average of the three readings. They shall be reported to the nearest ¼ inch.

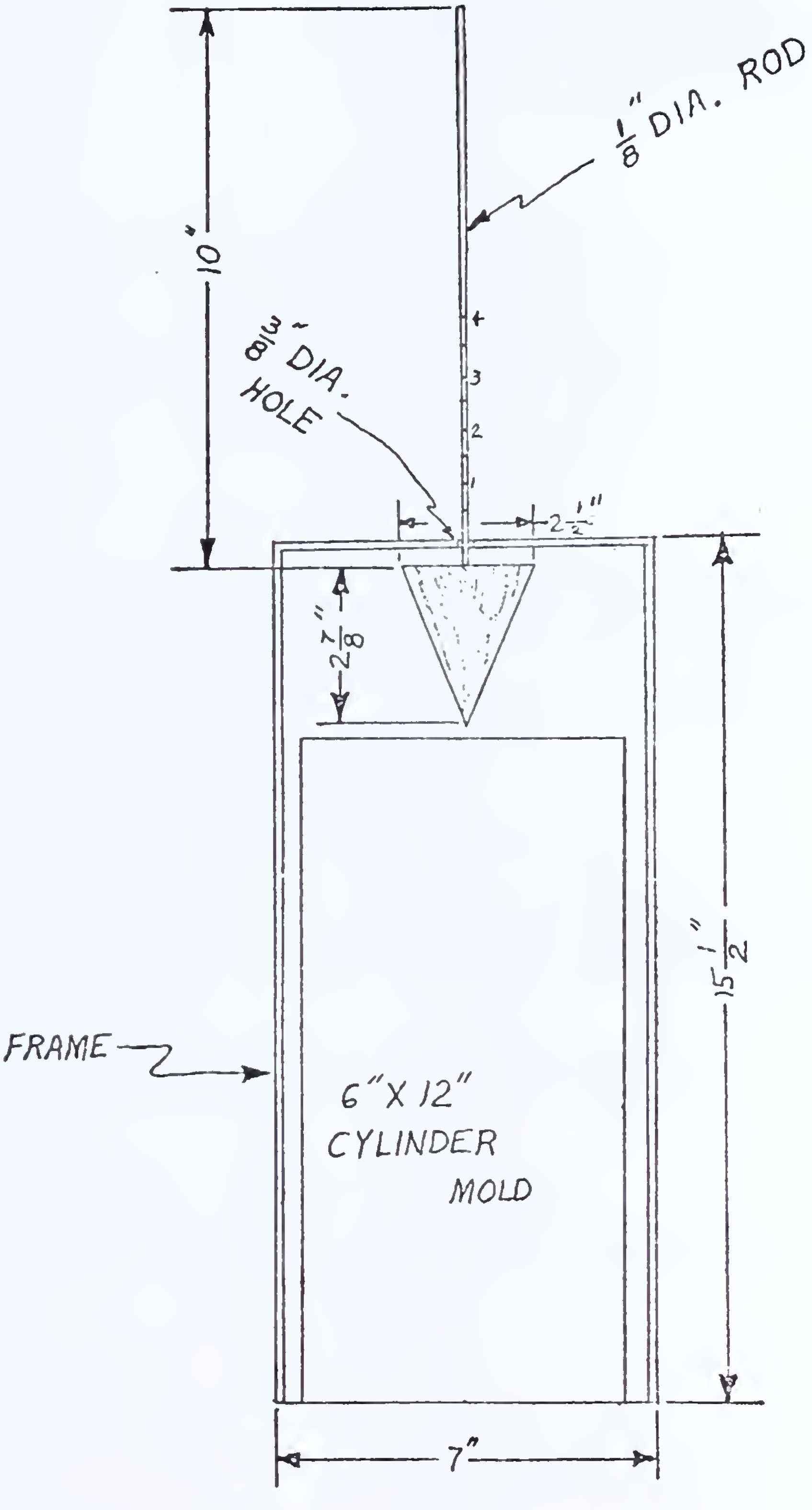


Fig. 1 — Cone Penetration Apparatus

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 629
June 1976
3 Pages

Bureau of Materials, Testing and Research

Method of Test for

MEASURING THE DEPTH OF GROOVES IN CONCRETE PAVEMENTS WITH A MODIFIED TIRE TREAD DEPTH GAGE

1. Scope

1.1 This method of test describes the procedure for sampling, preparing and measuring the depth of grooves in bridge decks, concrete pavements and ramps using a Modified Tire Tread Depth Gage.

1.2 This method of test can measure the depth of grooves in concrete pavements produced by the following methods: Tine Finish, Broom Finish and Pavement Grooving.

2. Apparatus

2.1 Tire Tread Depth Gage — A gage, calibrated in increments of 1/32 inch and capable of measuring to a depth of 1/2 inch, shall be used. The gage end shall be modified to a shape suitable for the measruement.

2.2 Miscellaneous Equipment — Hand broom or brush, 12 inch ruler, 100 foot tape measure and notebook.

3. Sampling procedure for securing test area.

3.1 The lot size for bridge decks shall be the length of the span by the width of the lane or lanes in one direction.

3.2 The lot size for concrete pavements shall be a minimum of 5,000 square yards to a maximum of 10,000 square yards in one direction. If the contractor's production is below the minimum, the lot size shall be the square yards of pavement placed.

3.3 The lot size for ramps or separate lanes connecting with cross streets shall be the square yards of pavement placed in one direction.

3.4 A lot shall consist of 5 approximately equal sublots.

3.5 Within each sublot, one test area shall be randomly secured in accordance with PTM No. 1.

4. Preparing the test area.

4.1 Brush all loose material from the area to be measured.

5. Measuring the depth of the grooves.

5.1 Measure ten grooves in a straight line perpendicular to the grooves, starting with the point that was randomly secured in Section 3.5

5.2 Place the Tire Tread Depth Gage on the groove to be measured and firmly seat it to the surface. Make sure that the needle point will fall in the middle of the groove.

5.3 Depress the needle point and determine the depth by reading the scale attached to the gage.

5.4 Repeat the procedures described in Sections 5.2 and 5.3 for the nine remaining grooves.

6. Calculations

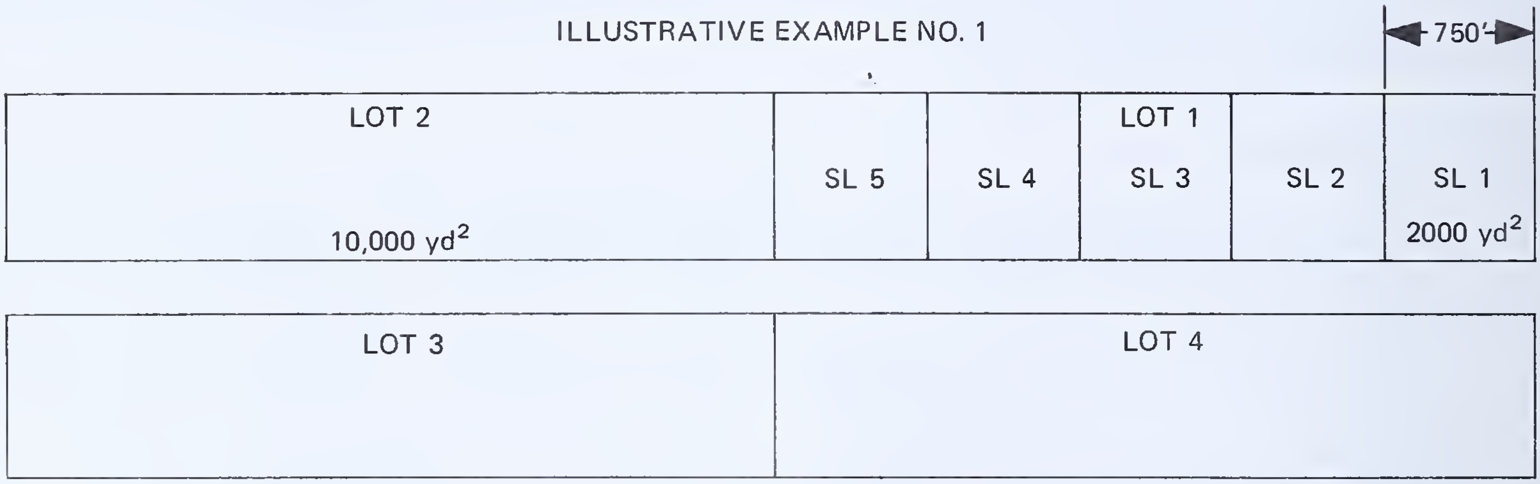
6.1 Calculate the average groove depth for each of the 5 sublots.

6.2 Calculate the average groove depth for the lot.

7. Report

7.1 The average groove depth for the lot shall be reported in increments of 1/32 inch.

ILLUSTRATIVE EXAMPLE NO. 1



Assume a contractor places 40,000 square yards of separated highway consisting of reinforced cement concrete pavement 24 feet wide on each side of a traffic separator.

In this case, the pavement can be divided into 4 lots. Each lot will have an area of 10,000 square yards.

Each lot must then be divided into 5 approximately equal sublots. Each sublot will have an area of 2,000 square yards (750 feet by 24 feet).

Assume beginning station is 100 + 00.

Use Table 2 from PTM No. 1 to obtain random decimal fractions in the X and Y columns. These values shall be multiplied by the length and width of the lanes of each sublot to obtain the coordinates of the sample location measured from the starting point of each sublot.

Sublot #1

Coordinate X = 0.47 x 750'= 352.5'

Coordinate Y = R 0.20 x 24' = R 4.8'.

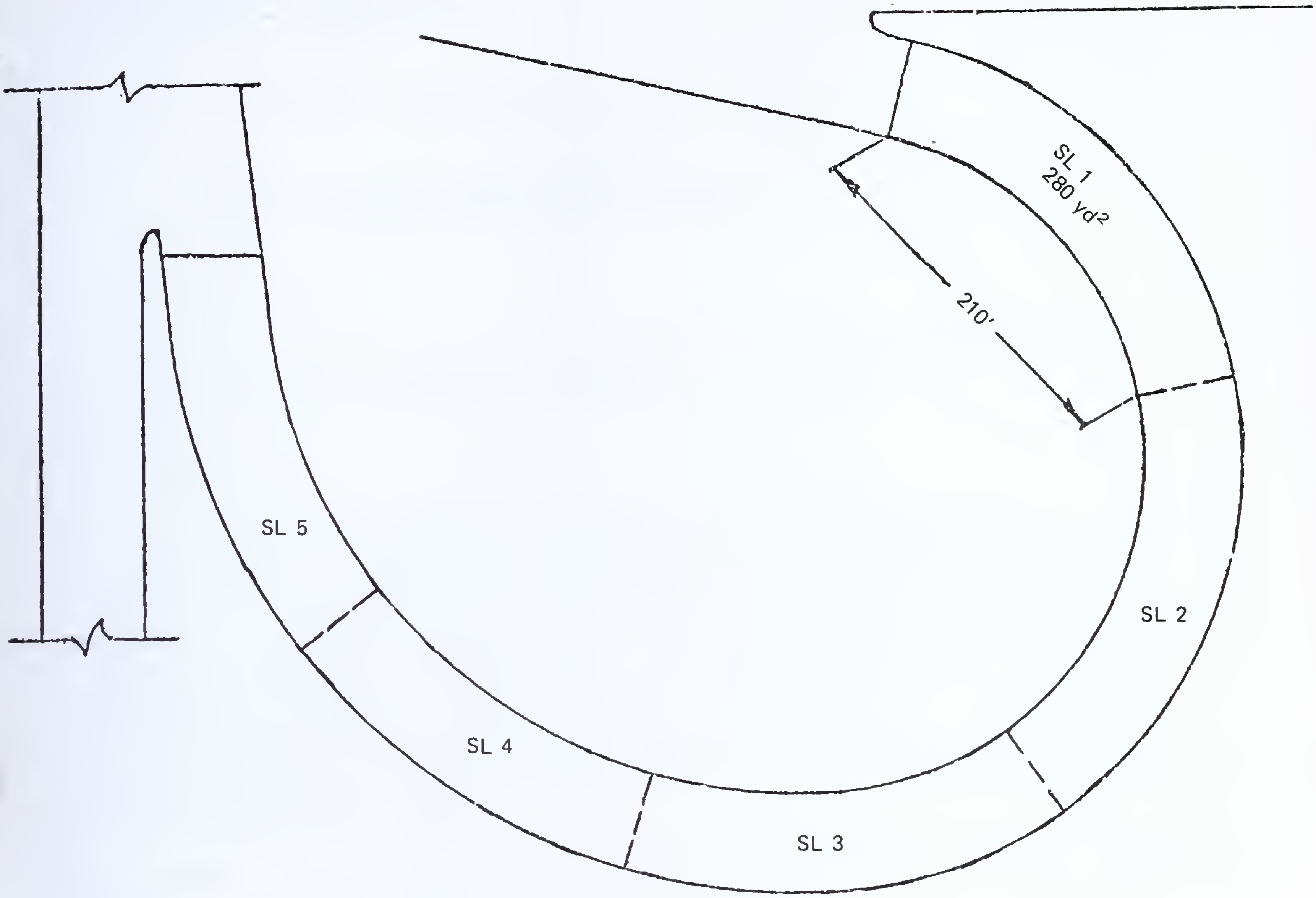
Sample Location = Sta. 100 + 00 plus 352.4'= Sta. 103 + 52.5

Measure 4.8' from Rt. edge of lane

Calculate the coordinates for the remaining sublots.

Be sure to go through Table 2 before using the same numbers over.

ILLUSTRATIVE EXAMPLE NO. 2



Assume a contractor places a ramp having an area of 1400 square yards.

In this case, the area of the ramp is the lot size. The lot shall begin where the uniform width starts and end at a point with a uniform width.

The lot must then be divided into 5 approximately equal sublots. Each sublot will have an area of 280 square yards (210 feet by 12 feet).

Measurements for the sublots and X coordinates shall be made along the inner edge.

The Y coordinate shall be measured on a line perpendicular to the sides of the ramp at the X coordinate point.

See ILLUSTRATIVE EXAMPLE NO. 1 for example of how to obtain the coordinates of the sample location.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 631
October, 1975
5 Pages

Bureau of Materials, Testing and Research
Method of Test for

MAKING AND CURING CONCRETE COMPRESSION SPECIMENS IN PRESTRESSED CONCRETE PLANTS

1. Scope

1.1 This method covers procedures for making and curing specimens of concrete sampled from concrete being used in prestressed concrete beam fabrication.

2. Apparatus

2.1 Molds for Compression Test Specimens. The molds shall be cylindrical machined metal. The plane of the rim of the mold shall be normal to its axis. The molds shall not vary from the prescribed diameter (Section 6) by more than 1/16 in. nor from the prescribed length (Section 6) by more than 1/4 in. No two diameters shall differ more than 1/8 in. from each other. Metal molds shall be provided with a machined metal base plate. The mold shall stand upright on its base plate or bottom and the top end shall be open to receive the concrete. The assembled mold and base plate or bottom shall be oiled with a light coat of mineral oil before use. The assembly shall be watertight, and a suitable sealant used where necessary to prevent leakage through the joint.

Note 1. Split molds shall be machined inside, to ensure perfectly round shape, after splitting and clamping.

2.2 Tamping Rod. The tamping rod shall be a round, straight steel rod, 5/8 in. in diameter and approximately 24 in. in length, having one end rounded to a hemispherical tip, the diameter of which is 5/8 in.

2.3 Vibrators. Internal vibrators may have rigid shafts or flexible shafts, preferably powered by electric motors. The frequency of vibration shall be 7000 rpm or greater. The outside diameter of the vibrating element shall be not smaller than 0.75 in. nor greater than 1.50 in. The length of the shaft should be at least 24 in.

2.4 Small Tools. Tools and items such as shovels, rubber mallet, trowels, straight-edge, scoops, and rulers shall be provided.

2.5 Slump Apparatus. The apparatus for measurement of slump shall conform to the requirements of the Method of Test for Slump of Portland Cement Concrete (PTM 600).

2.6 Sampling and Mixing Receptacle. A suitable pan, wheelbarrow, or flat, clean nonabsorbent mixing board of sufficient capacity to allow easy mixing by shovel or trowel of the entire sample shall be provided.

2.7 Air Content Apparatus. The apparatus for measuring air content shall conform to the requirements of the Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method (PTM 612) or the Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method (PTM 615).

3. Sampling Concrete

3.1 Samples of concrete for test specimens shall be taken in accordance with the Method of Sampling Fresh Concrete (PTM 601). The place of depositing the load of concrete that was sampled shall be noted in the job records (concrete "pour" book).

4. Slump and Air Content

4.1 Slump. The slump of each load of concrete sampled for test specimens shall be measured, immediately after sampling in accordance with PTM 600. Concrete used for the slump test shall be discarded.

4.2 Air Content. The air content of each load sampled for test specimens shall be determined in accordance with either PTM 615 or PTM 612. Concrete used for determination of air content shall be discarded.

5. Molding Specimens

5.1 Place of Molding. Specimens shall be molded as near as practicable to the place where they are to be stored during the curing cycle. It is not practicable to mold the specimens where they will be cured, therefore, they may be carefully moved after being struck off to their final curing position at any time during the initial curing phase.

5.2 The concrete shall be consolidated by internal vibration. In cases of emergency, such as mechanical failure or breakdown, rodding will be permitted.

5.3 Placing the Concrete. The concrete shall be placed in the molds in two layers using a scoop. In placing each portion of concrete, the scoop shall be moved around the top edge of the mold as the concrete is discharged in order to ensure a symmetrical distribution of the concrete and minimize segregation of the coarse aggregate within the mold. After consolidation, the surface of the concrete shall be struck off without undue manipulation using a straightedge or trowel, and all specimens covered immediately with wet burlap to prevent evaporation.

COMPRESSION TEST SPECIMENS

6. Specimens

6.1 Size of Specimens. Compression test specimens shall be cylindrical, with a length equal to twice the diameter. The standard specimen shall have a diameter of 6 in.

7. Method of Consolidation - refer to 5.2

7.1 Vibration. A standard duration of vibration shall be observed for the particular kind of concrete, vibrator and specimen mold involved. Vibration shall be continued only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation. The mold shall be filled and vibrated in two approximately equal layers. All of the concrete for each layer shall be placed in the mold before starting vibration of that layer. The second layer shall be added so as to avoid overfilling by more than 1/4 in. After vibrating the second layer, enough concrete shall be added and worked into the surface concrete with a trowel to overfill the mold about 1/8 in. and then struck off. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Usually, sufficient vibration has been applied as soon as the surface of the concrete becomes relatively smooth in appearance.

7.1.1 Internal Vibration. Three insertions of the vibrator at different points shall be used for each layer. In compacting the bottom layer, the vibrator shall not be allowed to rest on the bottom or touch the sides of the mold. The vibrator shall penetrate through the second layer and into the bottom layer approximately 1 in. Care should be taken that the vibrator is withdrawn in such a manner that no air pockets are left in the specimen.

7.2 Rodding. The concrete shall be placed in the mold in three layers of approximately equal volume. Using the tamping rod with the hemispherical tip in contact with the concrete, each of the layers shall be rodded 25 strokes. The bottom layer shall be rodded throughout its depth. The strokes shall be distributed uniformly over the cross-section of the mold and for each upper layer shall penetrate about 1 in. into the underlying layer. If voids are left by the tamping rod, the sides of the mold shall be tapped lightly to close the voids.

8. Specimens - Trial Mix

8.1 Specimens for Checking the Strength of Concrete for Trial Mix Designs. Metal molds shall be placed on a rigid horizontal surface free from vibration and other disturbances. During the first 24 ± 2 hr. all test specimens shall be stored under conditions that maintain the temperature immediately adjacement to the specimens in the range of that of the beam curing cycle and will prevent lost of moisture from the specimens. After 24 ± 2 hr. of curing under the above conditions, the specimens shall be removed from the molds and stored in the same atmosphere and curing conditions as those planned for the beam until the time of test.

Note 1. A moist condition is that in which free water is maintained on the surface of the specimens at all times.

9. Capping Specimens

9.1 General Provisions. The ends of all compression test specimens that are plane within 0.002 in. shall be capped or ground plane. Capped surfaces shall not depart from a plane by more than 0.002 in. The planeness of the caps of every tenth specimen shall be checked by means of a straightedge and feeler gage, making a minimum of three measurements on different diameters. The capped surface of the specimen in contact with the lower bearing block of the testing machine shall not depart from perpendicularity to the axis of the cylinder by more than 0.5 deg (approximately equivalent to 1/8 in. in 12 in.) and the combined departure to the two capped surfaces from perpendicularity to the axis shall not exceed 3 deg. Caps shall be made as thin as practicable. Any capping material when tested as 2 in. cubes of the same age and composition as the caps of the concrete cylinder shall develop compressive strength greater than the anticipated strength of the concrete cylinder (Note 2). Caps made from mixtures of sulfur type materials shall be formed against metal plates. Metal plates shall be at least 1 in. greater in diameter than the specimen and shall not depart from a plane by more than 0.002 in. Adhesion of the caping material to the capping plate may be avoided by coating the plate with light machine oil or mineral oil. Suitable alignment devices should be used in conjunction with the plates to ensure that the specified perpendicularity of the caps and the axis of the specimen is attained. Surface roughness of newly finished metal plates shall not exceed that set forth in Table 4 of ASA B46.1 on Physical Specimens of Surface Roughness and lay of 125 mico-in. for any type of surface and direction of lay. The surface when new shall be free from gouges, grooves, or indentations beyond those caused by the finishing operations incidental to a surface roughness of 125 micro-in.

Note 2. The compressive strength of mixtures of sulfur and granular materials may be determined in accordance with Section 7.1 of the Specifications for Sulfur Mortar (ASTM Designation: C 287).

9.2 Sulfur and Granular Materials. Proprietary or laboratory prepared mixtures of sulfur and granular materials may be used and caps should be allowed to harden at least 1/2 hr. before the specimens are tested. A melting pot equipped with automatic temperature controls shall be used for heating these mixtures.

Note 3. Caution. Melting pots equipped with peripheral heating will ensure against accidents happening when reheating cooled sulfur mixtures which have a crusted-over surface. When using melting pots that are not so equipped, care should be exercised to avoid the buildup of pressure under the hardened surface crust by means of a metal rod which contacts the bottom of the pot and projects above the surface of the fluid sulfur mix as it cools. The rod should be of sufficient size to conduct enough heat to the top on reheating to melt a ring around the rod first and thus avoid the development of pressure.

Sulfur melting pots should be used under a hood to exhaust the fumes to outdoors. The proper range of pouring temperature is from 265 to 290 F. Since the flash point of sulfur is approximately 440 F, the mixture may ignite due to overheating, and heating over an open flame is dangerous.

Should the mixture start to burn, covering will snuff out the flame. If the flame is extinguished immediately, the sulfur mixture may be used for capping.

10. Curing Specimens for Prestressed Plant Control

10.1 All specimens shall be placed next to the beam, or may be suspended from the forms on a hanger or shelf designed for this purpose. Specimens shall receive the same cure as that specified for the beam. They shall be removed from the metal mold at the same time the forms are stripped and beams are removed from the bed. Specimens shall be tested in the moisture condition resulting from the specified curing treatment.

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SYMBOLS USED IN FORMULAS FOR BITUMINOUS MIXTURES

A = Aggregate No. 1
AA = Aggregate No. 2
B = Bitumen
Br = Bitumenometer
F = Filler
G = Specific gravity
GA = Specific gravity of Aggregate No. 1
GAA = Specific gravity of Aggregate No. 2
GB = Specific gravity of Bitumen
GF = Specific gravity of Filler
GS = Specific gravity of Solvent
GSM = Specific gravity of Sample, or Specimen
S = Solvent
Sm = Sample
T = Theoretical specific gravity
V = Volume
VA = Volume of Aggregate No. 1
VAA = Volume of Aggregate No. 2
VB = Volume of Bitumen
VBr = Volume of Bitumenometer
VF = Volume of Filler
Vo = Volumeter
VS = Volume of Sample, or Specimen
VVo = Volume of Volumeter
VWa = Volume of Water
W = Weight in grams
Wa = Water
WA = Weight of Aggregate No. 1
WAA = Weight of Aggregate No. 2
WAb = Weight of Absorbed water
WB = Weight of Bitumen
WBr = Weight of Bitumenometer
WF = Weight of Filler
WS = Weight of Solvent
WSa = Weight of Saturated specimen
WSm = Weight of Sample, or Specimen
WVo = Weight of Volumeter
WWa = Weight of Water

Abbreviations in accepted use

SVD = Solid Volume Density
VFA = Voids Filled with Asphalt
VMA = Voids in Mineral Aggregates

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 701
October 1971
6 Pages

Bureau of Materials, Testing & Research

Method of Test for

PENETRATION OF BITUMINOUS MATERIALS

1. Scope

1.1 This method describes a procedure for determining the penetration of semisolid and solid bituminous materials, and is a modification of AASHO T-49.

2. Outline of Method

2.1 The sample is melted and cooled under controlled conditions. The penetration is measured with a penetrometer by means of which a standard needle is applied to the sample.

2.2 Use Method A for all tests where the results will be used for acceptance of the material.

2.3 Method B is for determining if contamination has taken place.

NOTE 1–Method B is limited in precision, but may be used when the test results are correlated with the penetration determined by Method A using the same material.

3. Definition

3.1 The penetration of a bituminous material is the distance in tenths of a millimeter that a standard needle penetrates vertically into a sample of the material under fixed conditions of temperature, load, and time.

METHOD A

4. Apparatus

4.1 Penetration Apparatus. Any apparatus permitting movement of the spindle without appreciable friction and which is accurately calibrated to yield results in accordance with the description of the term penetration (Section 3) will be acceptable. When the needle is mounted in a ferrule, the weight of the moving spindle shall be 47.5 ± 0.05 g. Regardless of the type of mounting of the needle, the total weight of the needle and spindle assembly shall be 50.0 ± 0.1 g. Weights of 50.0 ± 0.05 g and 100.00 ± 0.05 g shall also be provided for total loads of 100 g and 200 g depending upon the conditions of test to be applied.

4.2 Needle. The needle, Fig. 1, shall be made from fully hardened and tempered stainless steel, grade 440-C or equal, Rockwell hardness C 57 to 60. It shall be approximately 50.8 mm (2 in.) in length and 1.00 to 1.02 mm (0.0394 to 0.0402 in.) in diameter. It shall be symmetrically tapered at one end to a cone whose angle shall be within the range of 8.67 and 9.67 over the entire cone length from full needle diameter, and whose axis shall be coincident with the needle axis within 0.0127 mm (0.0005 in) maximum runout (total indicator reading). After tapering, the point shall be ground off to a truncated cone, the smaller base of which shall be from 0.14 to 0.16 mm (0.0055 to 0.0063 in.) in diameter. The truncation shall be square with the needle axis within 2 deg, and the edge shall be sharp and free from burrs. The surface of the truncation shall be finished to a smoothness of 8 microinches (rms). The exposed length of the needle when mounted in the chuck of the penetration apparatus or in a ferrule shall be approximately 41.27 mm (1 5/8 in.). When the needle is mounted in a ferrule, the ferrule shall be a cylindrical rod, approximately 3.18 mm (1/8 in.) in diameter and 38.1 mm (1.5 in.) long, made of stainless steel or brass, in which the needle shall be rigidly and coaxially mounted. The weight of the ferrule - needle assembly shall be 2.5 ± 0.05 g (a drill hole is permissible at the end of the ferrule to control weight).

NOTE 2--The National Bureau of Standards will measure and certify the accuracy of penetration needles in accordance with the permissible variations given.

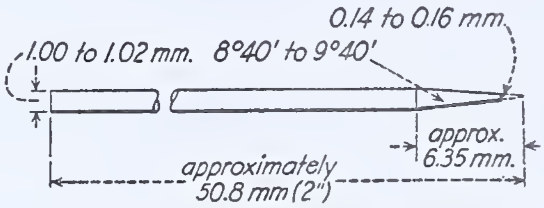


FIG. 1.—*Needle for Penetration Test.*

4.3 Container. A container, in which the sample is tested, made of metal or glass, cylindrical in shape, and having a flat bottom. The container to be used for materials having a penetration of 200 or less shall have a nominal capacity of 3 oz; its inside dimensions shall be essentially as follows: 55 mm (2.17) in diameter and 35 mm (1.38 in.) in depth. The container to be used for materials having a penetration over 200 shall have a nominal capacity of 6 oz; its inside dimensions shall be essentially as follows: 70 mm (2.75) in diameter and 45 mm (1.77 in.) in depth.

NOTE 3--Containers known as tin boxes or as seamless ointment boxes may be obtained in dimensions conforming to the above requirements.

4.4 Water Bath. A water bath maintained at a temperature varying not more than 0.2 F (0.1 C) from the temperature of the test. The volume of water shall not be less than 10 liters. The height of the bath shall be such that the sample can be immersed in the water to a depth of not less than 100 mm (4 in.) and be supported on a perforated shelf not less than 50 mm (2in.) from the bottom of the bath. Do not allow the water bath to become contaminated with oil or slime. Brine may be used in the water bath for determinations at low temperatures. If penetration tests are to be made without removing the sample from the bath, a shelf strong enough to support the penetration apparatus shall be provided.

4.5 Transfer Dish for Container. When used, the transfer dish for the container shall be a cylinder with a flat bottom made of glass, metal, or plastic. It shall be provided with some means which will insure a firm bearing and prevent rocking of the container. It shall have a minimum inside diameter of 90 mm (3.5 in.) and a minimum depth above the bottom bearing of 55 mm (2.17 in.).

4.6 Thermometers for Water Bath. The following thermometers conforming to the requirements prescribed in the Specifications for ASTM Thermometers (ASTM Designation: E-1) are recommended:

4.6.1 For tests at 77 F (25 C) use an ASTM Saybolt Viscosity Thermometer 17 C (or 17 F) having a range of (19 to 27 C) (66 to 80 F). The thermometer shall be immersed in the bath 150 ± 15 mm.

4.6.2 For tests at (0 C) (32 F) and (4 C) (39.2 F) use ASTM Precision thermometer 63 C (or 63 F) having a range of (–8 to + 32C) (18 to 89 F). The thermometer shall be immersed in the bath 150 ± 15 mm.

4.6.3 For tests at (46.1 C) (115 F) use ASTM Precision Thermometer 64 C (or 64 F) having a range of (25 to 55 C) (77 to 131 F). The thermometer shall be immersed in the bath 150 ± 15 mm.

4.6.4 Since the accuracy of the test results is dependent upon closely controlled temperature conditions, the thermometer used for the water bath should be accurately calibrated by the Method for Inspection, Test, and Standardization of Etched-Stem Liquid-in-Glass Thermometers (ASTM Designation: E-77).

4.7 Timing Device. A stop watch graduated in 0.1 sec intervals is recommended for use with a hand-operated penetrometer. An automatic calibrated timing mechanism attached to the penetrometer may be used.

5. Preparation of Sample

5.1 Heat the sample with care to prevent local over-heating until it has become fluid. Then with constant stirring raise the temperature of the asphalt sample (98 C) (177 F) to (108 C) (194 F) above its softening point, or the tarpitch sample not more than (56 C) (100 F) above its softening point, determined in accordance with the Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Apparatus) (AASHO T-53). Avoid the inclusion of air bubbles. Then pour it into the sample container to a depth such that, when cooled to the temperature of test, the depth of the sample is at least 10 mm greater than the depth to which the needle is expected to penetrate. Pour separate samples for each variation in test conditions.

5.2 Loosely cover each container and its contents as a protection against dust, and allow to cool in the atmosphere at a temperature not higher than (29.5 C) (85 F) and not lower than (21 C) (70 F) for not less than 1½ nor more than 2 hrs. when the sample is in a 6 oz container, not less than 1 nor more than 1½ hrs. when the sample is in a 3 oz container. Then place the sample in the water bath maintained at the prescribed temperature of test along with the transfer dish if used, and allow it to remain for not less than 1½ nor more than 2 hrs. when the sample is in a 6 oz container, and not less than 1 nor more than 1½ hrs. when the sample is in a 3 oz container.

6. Test Conditions

6.1 Where the conditions of test are not specifically mentioned, the temperature, load, and time are understood to be (25 C) (77 F), 100 g, 5 sec, respectively. Other conditions of temperature, load, and time may be used for special testing, such as:

Temperature	Load, g	Time, sec
(0 C) (32 F)	200	60
(4 C) (39.2 F)	200	60
(46.1 C) (115 F)	50	5

In such cases, the specific conditions of test shall be reported.

7. Procedure

7.1 Unless otherwise specified, place the 50 g weight above the needle, making the nominal total load 100 g for the needle and attachment. If tests are made with the penetration apparatus mounted in the bath, place the sample container directly on the submerged stand of the penetration apparatus. If tests are made with the sample in the bath and the penetration apparatus outside the bath, place the container on the shelf provided in the bath. In the above procedures the container shall be kept completely submerged during the complete test. If tests are made using the transfer dish with the penetration apparatus outside the bath, place the sample in a dish filled with water from the bath to a depth to cover completely the sample container. Then place the transfer dish containing the sample on the stand of the penetration apparatus and penetrate immediately. In each case, adjust the needle load with the specified weight to just make contact with the surface of the sample. Accomplish this by making contact of the actual needle point with its image reflected by the surface of the sample from a properly placed source of light (Note 4). Either note the reading of the dial or bring the pointer to zero. Then quickly release the needle for the specified period of time and adjust the instrument to measure the distance penetrated. Observe the sample container as the needle is applied, and if any movement of the container is noted, ignore the result.

NOTE 4--For referee tests, penetrations at temperature other than 77 F (25 C) should be made without removing the sample from the bath.

NOTE 5--The positioning of the needle can be materially aided by using an illuminated methyl methacrylate tube.

7.2 Make at least three penetrations at points on the surface of the sample not less than 10 mm (3/8 in.) from the side of the container and not less than 10 mm (3/8 in.) apart. If the transfer dish is used, return the dish and sample to the water bath after each penetrstion. Before each test clean the needle with a clean cloth, moistened with a suitable solvent to remove all adhering bitumen, and wipe with a clean dry cloth. For penetration values greater than 225, use at least three needles, leaving them in the sample until completion of the penetrations.

METHOD B

8. Apparatus

8.1 Penetration Apparatus. Refer to Section 4.1.

8.2 Needle. Refer to Section 4.2.

8.3 Sample Container. Made of metal, cylindrical in shape, and having a nominal capacity of ½ oz; its inside dimensions shall be essentially as follows: 33 mm (1 5/16 in.) in diameter and 14 mm (9/16 in.) in depth.

NOTE 6--Containers known as seamless ointment tins may be obtained in dimensions conforming to the above requirements.

8.4 Water Bath. A water bath with the dimensional requirements as in Section 4.4. The variation from the test temperatures shall be not more than 0.5 F (0.2 C).

8.5 Thermometer for Water Bath. ASTM Saybolt Viscosity Thermometer 17 F (17 C) having a range of 66 F to 80 F (19 to 27 C) conforming to the requirements of ASTM Designation: E-1.

8.6 Timing Device. Refer to Section 4.7.

9. Preparation of Sample

9.1 The sample shall not be cooled when taken from the tank car or truck but poured immediately.

9.2 Cool the sample container at room temperature for 15 min. Place in the water bath for a period of not less than 15 min. nor more than 30 min.

10. Test Conditions

10.1 The temperature, load, and time of this method are 77 F (25 C), 100 g, 5 sec, respectively.

11. Procedure

11.1 Place the 50 g weight above the needle, making the nominal total load 100 g for the needle and attachment. If tests are made with the penetration apparatus mounted in the bath, place the sample container directly on the submerged stand of the penetration apparatus. If tests are made with the sample in the bath and the penetration apparatus outside the bath, place the container on the shelf provided in the bath. In the above procedures the container shall be kept completely submerged during the complete test.

If tests are made using the transfer dish with the penetration apparatus outside the bath, place the sample in a dish filled with water from the bath to a depth to cover completely the sample container. Then place the transfer dish containing the sample on the stand of the penetration apparatus and penetrate immediately. In each case, adjust the needle loaded with the specified weight to just make contact with the surface of the sample. Accomplish this by making contact of the actual needle point with its image reflected by the surface of the sample from a properly placed source of light. Either note the reading of the dial or bring the pointer to zero. Then quickly release the needle for the specified period of time and adjust the instrument to measure the distance penetrated. Observe the sample container as the needle is applied, and if any movement of the container is noted, ignore the result.

11.2 Make at least three penetrations at points on the surface of the sample not less than 1 cm (3/8 in.) from the side of the container and not less than 1 cm (3/8 in.) apart. If the transfer dish is used, return the dish and sample to the water bath after each penetration. Before each test clean the needle with a clean cloth moistened with a suitable solvent to remove all adhering bitumen, and then wipe with a clean dry cloth.

12. Report

12.1 Method A. Report to the nearest whole unit the average of three penetrations whose values do not differ by more than the amount shown below:

Penetration	0 to 49	50 to 149	150 to 249	250 or over
Maximum difference between highest and lowest determinations	2	4	6	8

12.2 Method B. Report to the nearest whole unit the average of three penetrations whose values do not differ by more than four points.

12.3 Correct the penetration by adding or subtracting the difference between the average penetration of Method "B" and Method "A" to the value obtained in Section 11.2.

13. Precision

13.1 Method A. Repeatability. Two results obtained by the same operator on the same sample in the same laboratory using the same apparatus, and on different days should be considered suspect if they differ by more than the following amounts:

Asphalts at 77 F (25 C) below 50 penetration-------1 unit
Asphalts at 77 F (25 C) 50 penetration and above-------3 percent of their mean
Tar pitches at 77 F (25 C)------15 percent of their mean

13.2 Reproducibility. Two results obtained by different operators in different laboratories on different days should be considered suspect if they differ by more than the following amounts:

Asphalts at 77 F (25 C) below 50 penetration------- 4
Asphalts at 77 F (25 C) 50 penetration and above------8 percent of their mean
Tar pitches at 77 F (25 C)----- 4 units *

* Tar pitches estimates of precision are based on results from 2 pitches with penetration of 7 and 24. Estimates may not be applicable to appreciably harder or softer materials.

NOTE 7--Section 13 is not applicable to Method B.

NOTE 8--Values shown above were obtained by multiplying the estimates of the following population standard deviations by:

	Standard Deviation within Laboratory	Standard Deviation between Laboratories
Asphalts at 77 F (25 C) below 50 penetration	0.35 units	1.4 units
Asphalts at 77 F (25 C), 50 penetration and above	1.1 percent of their mean	2.8 percent of their mean
Tar pitches at 77 F (25 C)	5.2 percent of their mean	1.4 units

The estimates of precision listed in the adjoining table are based on the following data:

	Asphalts Below 50 Penetration	Asphalts of 50 Penetration & above	Tar Pitches
Samples	2	7	2
Laboratoires	16	27	19
Replicates per sample	3	3	3
Degrees of Freedom:			
within laboratory	32	185	38
Between laboratories	14	89	17

14. References

AASHO T 49-
ASTM D 5-

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 702
October 1971
14 Pages

Bureau of Materials, Testing & Research

Method of Test for

QUANTITATIVE EXTRACTION OF BITUMEN FROM BITUMINOUS PAVING MIXTURES

1. Scope

1.1 This method covers procedures for the quantitative determination of bitumen in hot-mixed paving mixtures and pavement samples, and is a modification of AASHO T-164-

NOTE 1--Although bitumen, by definition, is material soluble in carbon disulfide either 1,1,1, trichloroethane or trichloroethylene is used in this method for safety reasons. Benzene may also be used when an absen recovery will be made on the extract liquid.

2. Summary of Methods

2.1 The paving mixture is extracted with trichloroethane (or benzene) using the extraction equipment applicable to the particular method. The bitumen content is calculated by difference from the weight of the extracted aggregate, moisture content, and ash from an aliquot part of the extract. A bitumenmeter may be used to determine the bitumen percent and the difference from the total weight of sample is the percent of aggregate.

3. Reagents

3.1 Ammonium Carbonate. Saturated solution of reagent grade ammonium carbonate $(NH_4)_2CO_3$.

3.2 1,1,1, Trichloroethane, conforming to Federal Specifications O-T-620 (Int. Amp. 3), refer to Sec. 17.1 (Method D) for requirements when the bitumenmeter is used for bitumen content.

3.3 Trichloroethylene, Technical Grade, Type 1, Federal Specifications O-T-634, latest revision.

4. Preparation of Sample

4.1 If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large, flat pan and warm to 325 F (163C) only until it can be handled. Separate the particles of the mixture as uniformly as possible using care not to fracture the mineral particles. Care should be taken to avoid overheating the sample or leaving the sample in the oven for too long of a period. The maximum permissable time in the oven shall be 2 hours.

4.2 Recommended approximate sizes of the sample have been given in the test methods.

NOTE: In no case should the selection of a sample of a predetermined weight be attempted.

5. Water Determination

5.1 Weigh 500 g of the sample into a metal still conforming to the Method of Test for Water in Petroleum Products and other Bituminous Materials, PTM 727- (ASTM Designation D 95) and determine water content by this procedure.

NOTE 2--The Water Determination test is conducted only when water is known to be present or if its presence is suspected.

METHOD A

6. Apparatus

6.1 Extraction apparatus, consisting of a bowl which may be revolved at controlled variable speeds up to 3600 rpm. (Fig. 1). The apparatus shall be provided with a container for catching the solvent thrown from the bowl and a drain for removing the solvent. The apparatus preferably shall be provided with explosion-proof features and installed in a hood to provide ventilation.

NOTE 3--Similar apparatus of larger size may be used.

6.2 Filter rings, to fit the rim of the bowl.

6.3 Oven, capable of maintaining the temperature at 325 F. (163 C).

6.4 Pan, flat, 12 in. (30 cm) long, 8 in. (20 cm) wide and 1 in. (2.5 cm) deep.

6.5 Balance, capable of weighing 5000 g to an accuracy of 0.1 g.

6.6 Small mouth graduated cylinder, 1000 ml capacity.

6.7 Small mouth graduated cylinder, 100 ml capacity.

6.8 Ignition dish, 125 ml capacity.

6.9 Desiccator

6.10 Analytical Balance

7. Procedure

7.1 Weigh approximately 1000 to 2500 g sample into the bowl to the nearest 0.1 g. In no case the wearing course and binder samples shall be less than 500 g and 1000 g respectively.

7.2 Cover the sample in the bowl with trichloroethane or trichloroethylene and allow sufficient time for the solven to disintegrate the sample (not over 1 hr.). Place the bowl containing the sample and the solvent in the extraction apparatus. Dry and weigh filter ring and place it around the edge of the bowl. Clamp the cover on bowl tightly and place a beaker under the drain to collect the extract.

7.3 Start the centrifuge revolving slowly and gradually increase the speed to a maximum of 3600 rpm or until solvent ceases to flow from the drain. Allow the machine to stop, add 200 ml of solvent and repeat the procedure. Use sufficient 200 ml solvent additions (not less than three) so that the extract is clear and not darker than a light straw color. Collect the extract and the washings in a suitable graduate.

7.4 Remove the filter ring from the bowl and dry in air. Remove as much of the mineral matter adhering to the ring as possible and add to the aggregate in the bowl. Dry the ring to constant weight in an oven at 325 F (163 C). Dry the contents of the bowl to constant weight in an oven at 325 F (163 C).

7.5 Record the volume of the total extract in the graduate. Agitate the extract thoroughly and immediately measure approximately 100 ml into a previously weighed ignition dish. Evaporate to dryness on a hot plate. Ash residue at a dull red heat (500 to 600 C), cool, and add 5 ml of saturated ammonium carbonate $(NH_4)_2CO_3$ solution per gram of ash. Digest at room temperature for 1 hr. Dry in an oven at 230 F (110 C) to constant weight, cool in desiccator, and weigh.

8. Calculations

8.1 Calculate the weight of ash in the total volume of extract as follows:

$$\text{Total ash, g} = G \frac{V_1}{V_1 - V_2}$$

where:

G = ash in aliquot in grams,
V_1 = total volume in milliliters, and
V_2 = volume of aliquot in milliliters.

8.2 Calculate the percentage of bitumen in the sample as follows:

NOTE 4--In routine practice, calculation is simplified by use of a nomograph prepared with reference to the encountered range of the variables in the formula given above in Appendix I.

$$\text{Bitumen content of dry sample, percent} = \frac{(W_1 - W_2) - (W_3 + W_4)}{W_1 - W_2} \times 100$$

where:

W_1 = weight of sample,
W_2 = weight of water in sample,
W_3 = weight of extracted mineral matter, and
W_4 = weight of ash in extract.

NOTE 5--Add the increase in weight of the filter ring to the weights of the recovered aggregate and the ash in the recovered bitumen.

METHOD B

MARYLAND METHOD FOR EXTRACTING BITUMEN FROM PAVING MIXTURES

9. Scope

9.1 This method of test is intended for the determination of the percentage of bitumen in a paving mixture the aggregate of which all pass a three inch screen. It is not intended for use in recovering the bitumen for further testing. The mineral matter recovered from this test however, can be used for sieve analysis.

10. Apparatus

10.1 Extraction Apparatus consisting of a stainless steel container, condensor lid and stand approximating that shown in Figure 2. The apparatus preferably shall be installed under a hood or other well ventilated areas.

10.2 Basket for sample as shown in Figure 2. A number four (4) or heavier screen shall be placed in the basket to support the sample.

10.3 Filter Cloth of approximately 200 mesh - 16XX Swiss Stencil Cloth is suitable - placed over No. 4 screen and shaped to cover completely inside of basket.

10.4 Graduate, 2000 ml capacity.

10.5 Balance, capacity of 15 kg - sensitivity 1.0 gram.

10.6 Balance, capacity of 4.5 kg - sensitivity .1 gram.

10.7 Thermometer, accurate to .2 F and covering a temperature range of 66 to 80 F conforming to the requirements for thermometer 17 F as prescribed in ASTM Specifications E-1.

10.8 Gas Ring Burner or suitable heat source.

10.9 Scraper to loosen asphalt and fine mixture on bottom of extractor.

10.10 Rubber Gloves, Gas Mask, Trowel, Rubber Tubing, etc.

11. Reagent

11.1 Trichlorethane, maintaining a constant Specific Gravity over the entire refluxing period.

12. Preparation of Sample

12.1 Samples do not have to be heated prior to extracting but should be thoroughly dry. The sample size shall be between 3500 and 11,000 grams. Weigh basket assembly, place sample in basket and obtain total weight to 1 gram.

13. Procedure

13.1 Place the basket with sample in the extractor. Pour over it 1150 to 1250 ml of trichlorethane. Put extractor lid tightly in place and allow water to circulate freely in the top. Apply heat from a gas ring burner. The sample should be allowed to reflux until all asphalt is leached from the mix. This will normally take 1½ to 3 hours depending upon sample size and type.

13.2 After extracing the sample for 1½ hours the extractor will be shut down and sample inspected. Mix the sample with a trowel then allow it to extract to completion. Care shall be taken that the amount of solvent in the extractor is sufficient to cover the bottom. A sample is completely extracted when upon inspection no discoloration is found either on the aggregate or on the surface of a trowel which has mixed the sample thoroughly. Remove the sample and dry to constant weight.

13.3 Scrape the bottom of extractor to loosen fines and asphalt mixture. Drain extractor into the graduate. Rinse extractor with clean solvent until free of any residue and add these washings to the graduate containing original liquor.

13.4 Record the volume of the total extract in the graduate. Agitate the extract thoroughly and immediately measure approximately 100 ml into a previously weighed ignition dish. Evaporate to dryness on a hot plate. Ash residue at a dull red heat (500 to 600 C), cool, and add 5 ml of saturated ammonium carbonate $(NH_4)_2CO_3$ solution per gram of ash. Digest at room temperature for 1 hr. Dry in an oven at 100 C to constant weight, cool in desiccator, and weigh.

13.5 When using the bitumenometer method of bitumen determination follow the procedure as shown in Sec. 19.5.

14. Calculations

14.1 Calculate the percentage bitumen in the sample as described in Sec. 8, if the ash method is used or as in Sec. 20 when using the bitumenometer.

METHOD D

15. Scope

15.1 This method of test is intended for the determination of the percentage of bitumen in a paving mixture in which the aggregate size does not exceed 2½ inches (Note 4). The sample is first immersed in hot solvent, for rapid disintegration of the mixture and extraction of the bitumen, and is then thoroughly washed by refluxing to complete the extraction. The percentage of bitumen is determined by calculation from the specific gravities and the volume of the materials in the extract, determined by means of a pycnometer. The mineral matter recovered from either test can be used for sieve analysis.

NOTE 6--The methods are adaptable to paving mixtures in which aggregate size is up to 3½ inches by employing an extractor four times larger than that described herein and a larger pycnometer of 1500 ml capacity. The larger apparatus accommodates samples of up to 7000 g with larger size aggregate.

16. Apparatus

The apparatus shall consist of the following:

16.1 Extractor consisting of an extraction kettle of stainless steel or borosilicate glass, with perforated basket and condenser top, approximating the apparatus shown in Fig. 3. Underside of condenser shall be covered with numerous rounded knobs to distribute condensed solvent uniformly onto surface of sample. The suspension of the basket shall be arranged to support the basket ½ inch above bottom of kettle for immersion of sample in solvent, and 4 inches above bottom of kettle for refluxing. The apparatus preferably shall be used under a hood to provide ventilation. 1000 or 2000 size extractor may be used.

16.2 Cloth Filter Sacks with elasticized hem for lining the basket.

16.3 Hot Plate of at least 600 watts capacity with variable control, capable of maintaining the solvent at boiling temperature. Burner may be used if noninflammable solvent is employed.

16.4 Balance with a capacity of between 1000 and 5000 g sensitive to 0.1 g or 10,000 g capacity with 1 g sensitivity, for large size extractor.

16.5 Tare Pan, at least 6 inches diameter.

16.6 Bitumenometer (Pycnometer) approximately 750 ml capacity, as shown in Fig. 3, calibrated to nearest 0.1 ml or 1500 ml capacity for larger size extractor.

16.7 Thermometer range 66 to 80 F conforming to the requirements for thermometer 17 F as prescribed in ASTM Specifications E-1.

16.8 Cold Water Bath, Metal Funnel, Washing Bottle, Brush, etc.

17. Solvent

17.1 1,1,1, Trichloroethane or trichloroethylene. For bitumenometer method of extract analysis, specific gravity of solvent must be known within 0.001 and must remain constant after 20% distillation loss.

18. Preparation of Sample

18.1 If the mixture is not sufficiently soft to separate with a spatula or trowel, place 2000 to 5000 g in a pan and warm in oven at 325 F (163 C) for a maximum time of two hours or on hot plate over low heat, until it can be handled. Use care not to fracture the mineral particles. Insert a filter sack in the extractor basket and weigh these with tare pan to determine total tare weight. Weigh into the filter sack a representative sample of the mix not less than 500 g if maximum aggregate size is less than ½ inch. If maximum aggregate size is ½ to 2½ inches, weight of the sample shall not be less than 1000 g. All weighings shall be to nearest 0.1 g. Larger samples up to 7000 g may be tested by using the larger apparatus. In no case, however, should the selection of a sample of a predetermined weight be attempted.

19. Procedure

19.1 Attach suspension rod to loaded basket and set the assembly into extraction kettle. Pour approximately 600 ml of solvent over sample. Set condenser cover in place on kettle. Provide flow of cold water in place on kettle. Provide flow of cold water through condenser lid.

19.2 Raise basket to immersion level, i.e. ½ inch above bottom of kettle, by inserting support pin through upper hole of suspension rod. Place extractor on hot plate, or over burner, and adjust heating rate so that solvent is maintained at gentle boil. Avoid vigorous boiling which might wash fines over sides of basket. Continue heating with sample in immersion position for 15 to 30 minutes, depending upon composition, size and age of sample.

19.3 Raise basket to refluxing level, i.e. 4 inches above bottom of kettle, by inserting support pin through lower hole of suspension rod. Increase heat and maintain active boiling for 15 to 30 minutes, or until solvent dripping from the basket appears colorless. If stainless steel kettle is used, solvent can be examined by lifting out the basket and condenser assembly.

19.4 Remove extractor from heat source and allow to cool for several minutes. Lift out basket and condenser assembly. Cover kettle. Remove filter sack, distribute its contents onto tare pan in which sample was originally weighed, and dry on hot plate over low heat, or in an oven at 325 F (163 C) to constant weight, with filter sack on top of aggregate. Use care not to char sack. Cool, place extractor basket onto pan, and weigh assembly of aggregate, filter sack, extractor and tare pan. Subtract total tare weight from this weight and record as weight of extracted aggregate.

19.5 While aggregate is being dried, set covered kettle in cold water bath 2 to 4 inches deep to hasten cooling to approximately 80 F. Transfer extract to bitumenometer, using a funnel. Wash down inside of kettle with solvent, adding this and enough additional solvent to fill bitumenometer to base of neck. Air bubbles must be eliminated. Adjust temperature of bitumenometer contents to 77.0 F (Note 5). Insert volume adjustment stopper, fill stopper capillary and apply overflow cap. Dry outside of bitumenometer and weigh to nearest 0.1 g. Subtract weight of bitumenometer from this weight and record as weight of extract. Record actual temperature of extract to nearest 0.2 F at time of weighing.

NOTE 7--Correction can be applied for extract temperature differing from 77.0 F, between 74 and 80 F. Corrections for solvents can be computed from their specific gravity and coefficient of expansion.

20. Calculations

20.1 Calculate the percentage bitumen in the sample as follows:

$$= \frac{G_2}{W_1 (G_3 - G_2)} \times \left[G_3 \left(V_1 - \frac{W_2 + W_3 - W_1}{G_1} \right) + W_3 - W_1 \right] \times 100$$

where:

G_1 = specific gravity of solvent at 77.0 F,
G_2 = specific gravity of bitumen at 77.0 F,
G_3 = specific gravity of aggregate at 77.0 F,
V_1 = volume of bitumenometer at 77.0 F,
W_1 = weight of original dry sample,
W_2 = weight of extract, and
W_3 = weight of extracted aggregate.

NOTE 7--The above formula corrects for the amount of fines contained in the extract.

If the specific gravities for the materials in the extract are not known, they can be determined by means of the bitumenometer (pycnometer) in accordance with ASTM procedures.

20.2 Calculate weight of total aggregate in sample as follows:

Weight of total aggregate in sample

$$= W_1 - (\text{\% of bitumen in sample} \times \frac{W_1}{100})$$

NOTE 9-In routine practice, calculation is simplified by use of a nomograph prepared with reference to the encountered range of the variables in the formula given above in Appendix I.

21. Precision

The following data should be used for judging the acceptability of results (95 percent acceptability).

21.1 Duplicate results by the same operator should be considered suspect if they differ by more than the following amounts:

	Repeatability
Standard deviation, percent	0.12
Bitumen content, percent	0.34

21.2 The result submitted by one laboratory should not be considered suspect unless it differs from that of another laboratory by more than the following amounts:

	Reproducibility
Standard deviation, percent	0.20
Bitumen content, percent	0.56

NOTE 10– The precision statement is derived from 10 laboratories testing 4 samples with 3 replicates per test.

Explanatory Note

NOTE 11-Determination of Tar - for paving mixtures in which it is used as the binder, the tar content can be determined by the using of Methods A, B or C. The percent soluble is divided into the percent of bitumen as determined in Section 9.2 to calculate the total bitumen content of the sample. The extraction may be conducted by any of the above methods using benzene or quinoline as the solvent.

22. Reference

AASHO Method T-164
ASTM Method D-2172

Attachments:

Figures 1 thru 4
Appendix 1
Table 1 - Metric Equivalents

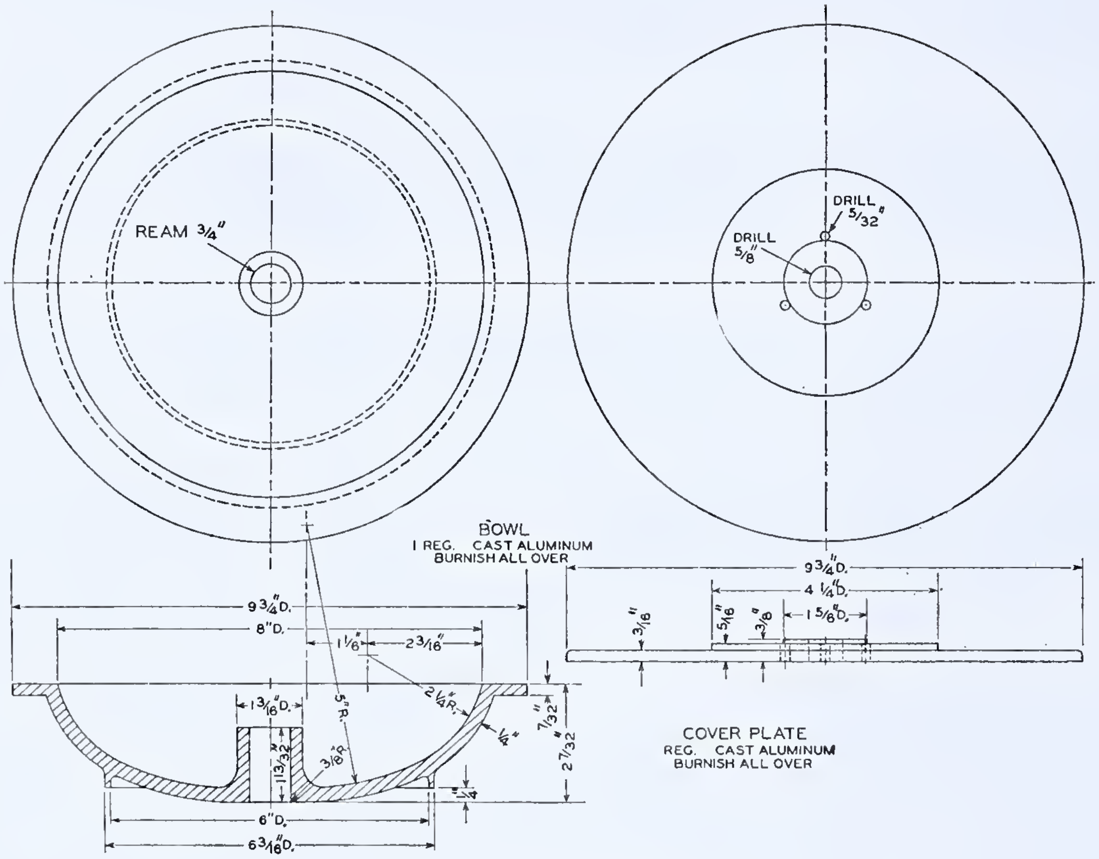
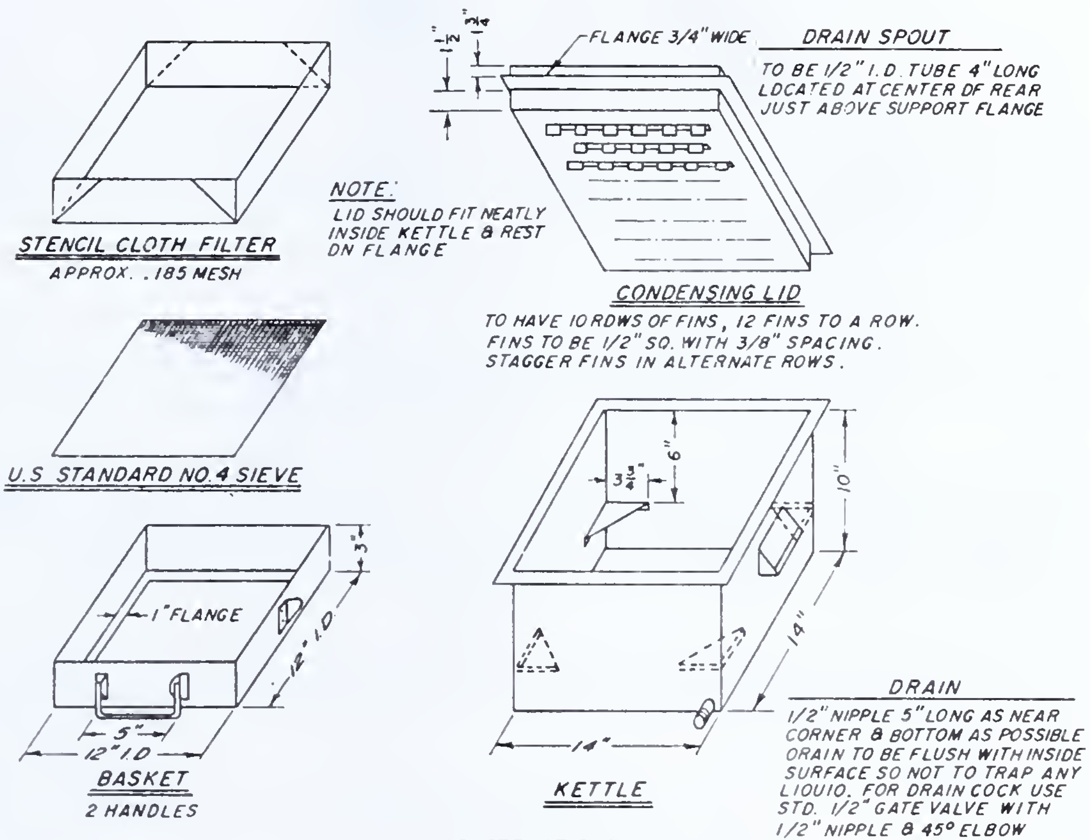


FIG. 1.—Extraction Unit Bowl.



DRAIN SPOUT
TO BE 1/2" I.D. TUBE 4" LONG LOCATED AT CENTER OF REAR JUST ABOVE SUPPORT FLANGE

NOTE:
LID SHOULD FIT NEATLY INSIDE KETTLE & REST ON FLANGE

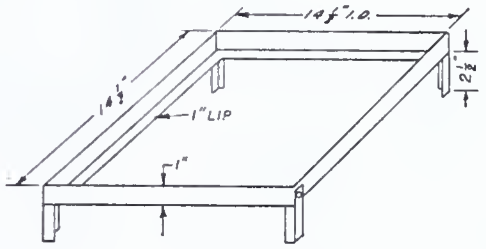
TO HAVE 10 ROWS OF FINS, 12 FINS TO A ROW. FINS TO BE 1/2" SQ. WITH 3/8" SPACING. STAGGER FINS IN ALTERNATE ROWS.

DRAIN
1/2" NIPPLE 5" LONG AS NEAR CORNER & BOTTOM AS POSSIBLE DRAIN TO BE FLUSH WITH INSIDE SURFACE SO NOT TO TRAP ANY LIQUID. FOR DRAIN COCK USE STD. 1/2" GATE VALVE WITH 1/2" NIPPLE & 45° ELBOW

CONSTRUCTION:
KETTLE LID AND BASKET TO BE OF 302-18-8, 16 GAUGE ST. STEEL

–Extractor Unit.

STAND MADE FROM 1" X 1" X 1/8" ANGLE IRON

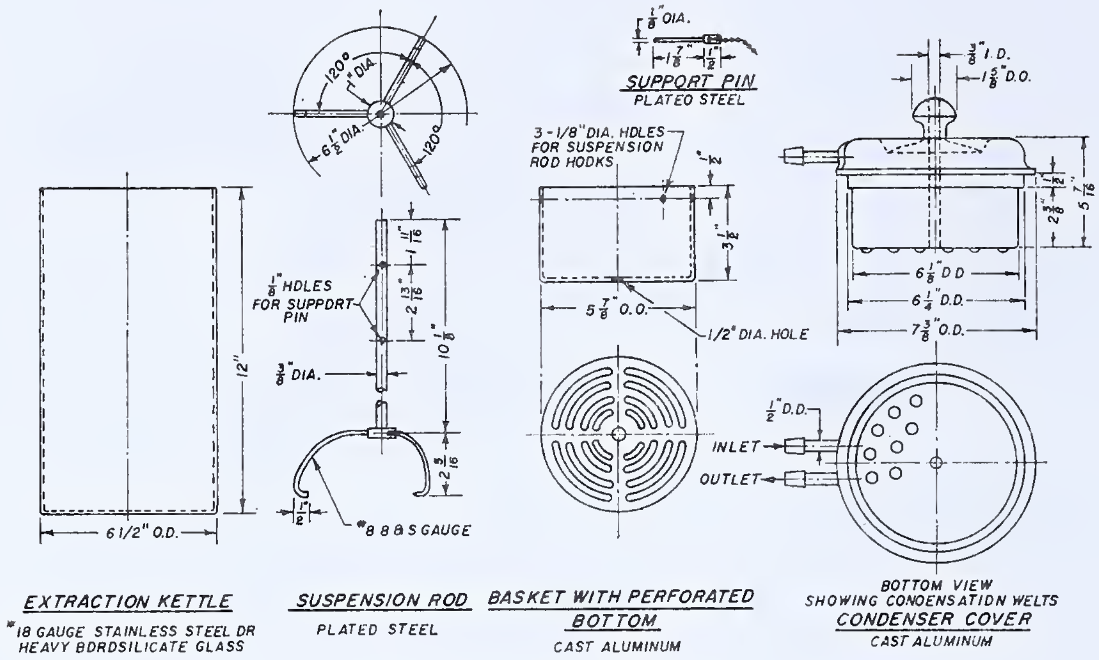


FRONT LEGS FIXED WITH SINGLE PIN TO ALLOW LEGS TO FOLD BACK WHEN DRAINING THE EXTRACTOR.

-Stand for Extractor Unit.

45–22

FIGURE 2



Extractor Unit.

FIGURE 3

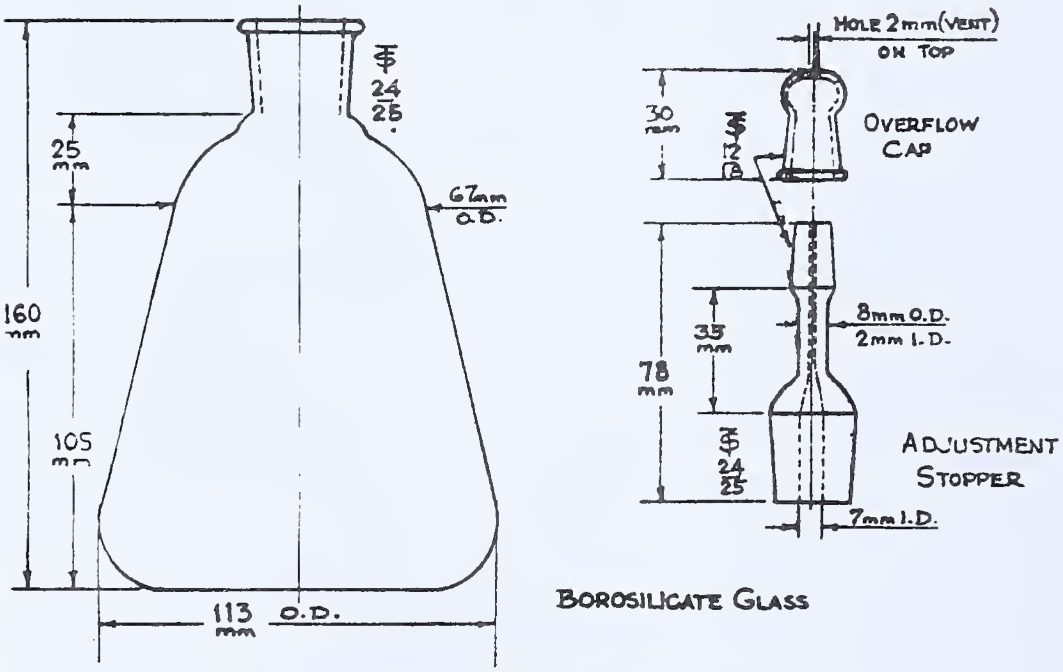


FIG. 4 - BITUMENOMETER. 750ml CAPACITY

APPENDIX I

EXPLANATION OF IMMEREX NOMOGRAPH

The Immerex nomograph is complete and can be used with any volume of bitumenometer or volumetric flask, and any solvent. It is based on the weight of extraction loss and volume of extraction loss. The range of this nomograph includes all bitumen with specific gravities between 1.00 and 1.04 and aggregates between 2.50 and 3.00.

The nomograph was constructed for use with 500 and 1000 gram samples; however, it can be used with any weight of sample, if the 1000 gram lines are used and the percentage of bitumen as read on the nomograph is multiplied by 1000 and the product is divided by the weight of the original sample.

Place straightedge to connect weight of extraction loss and volume of extraction loss on specific gravity line of the aggregate. Then, in case the specific gravity of bitumen is 1.00 - READ PERCENT OF BITUMEN AT POINT WHERE STRAIGHTEDGE INTERSECTS THE 1.00 BITUMEN SPECIFIC GRAVITY LINE.

In case the specific gravity of bitumen 77.0 F is greater than 1.00, then from point of intersection at the 1.00 bitumen specific gravity line project horizontally to the point where the horizontal line intersects with the actual bitumen specific gravity line, and READ PERCENT OF BITUMEN AT THIS POINT.

All specific gravity lines should be where the 1.00 specific gravity line is, but, since it is impossible to place all numerals on this line, additional lines were drawn for easier readings.

Required data for nomograph based on weight of extraction loss and volume of extraction loss.

Specific gravity of solvent @ 77.0 F = 1.59

Specific gravity of bitumen @ 77.0 F = 1.03

Specific gravity of aggregate @ 77.0 F = 2.77

Volume in cc of bitumenometer @ 77.0 F = 748.8

Weight of Original Sample = 1000.0
–Weight Extracted Sample = 948.9
Weight Extraction Loss = 51.1

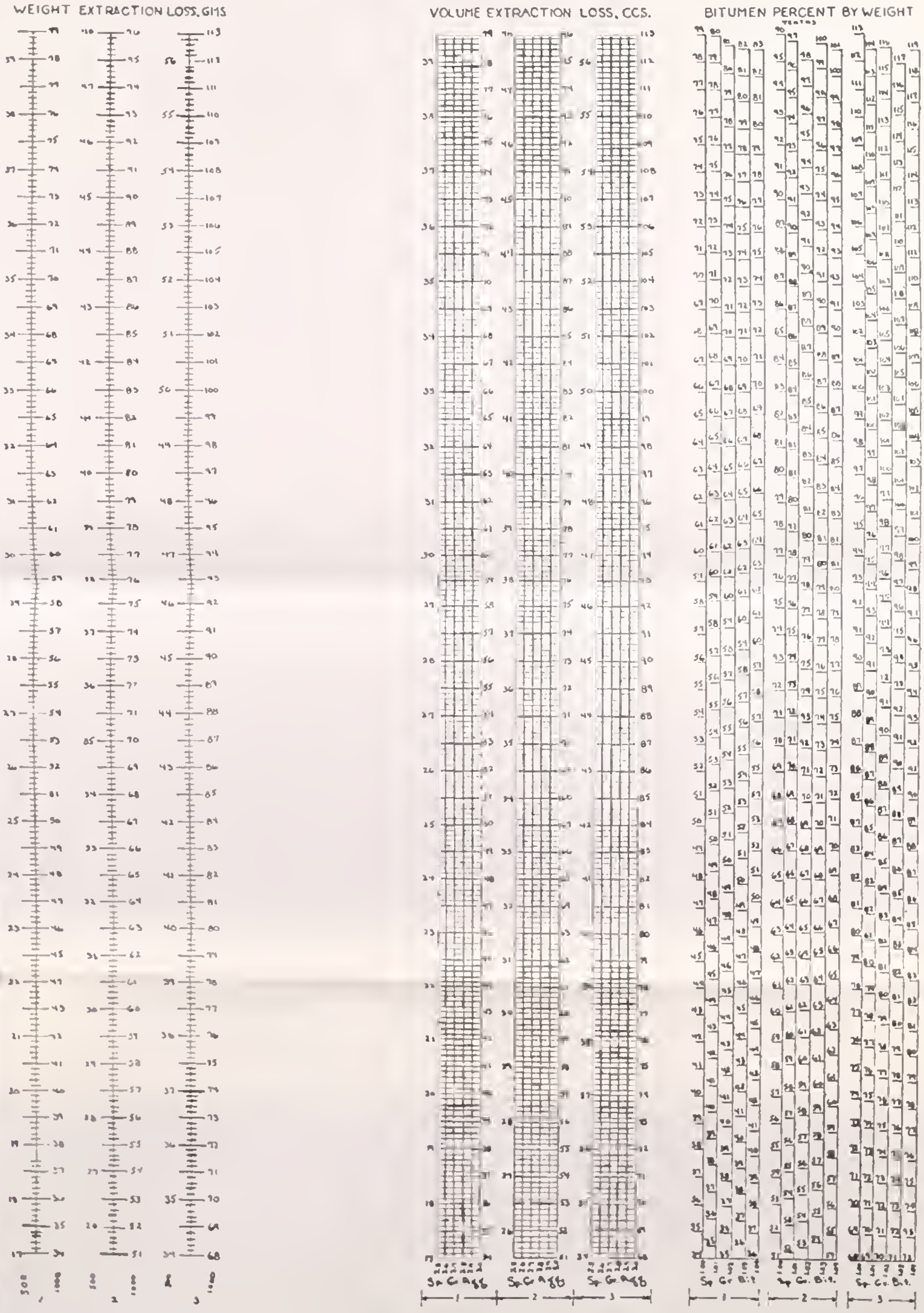
Weight Extract Liquid = 1168.7
–Weight Extraction Loss = 51.1
Weight of Solvent = 1117.6

÷Weight of Solvent [1117.6] = 702.8 Volume in cc of Solvent

Volume of Bitumenometer = 748.8
–Volume of Solvent = 702.8
Volume of Extraction Loss = 46.0

The accompanying nomograph illustrates this problem.

IMMEREX NOMOGRAPH



EXAMPLE

Place straightedge to connect the weight of extraction loss [51.1 grams] and volume of extraction loss [46.0 cc] in the 2.77 specific aggregate line of the aggregate. Then from the point the straightedge intersects the 1.00 bitumen specific gravity line, project horizontally to the point where the horizontal projected line intersects with the 1.03 bitumen specific gravity line. At this intersection read the percent of bitumen 4.5.

In cases where gradation of the aggregate is required, the fines which pass through the filter should be added to the amount passing the finest size sieve used in gradation. The fines can be determined as follows:

Weight of Extraction Loss	=	51.1
- Weight of Bitumen	=	45.0
Weight of Fines		6.1

TABLE 1 - METRIC EQUIVALENTS

U.S. Customary Units, in.	Metric Equivalent, cm	U.S. Customary Units, in.	Metric Equivalent, cm	U.S. Customary Units, in.	Metric Equivalent, cm
1/8	0.32	1 11/16	4.3	5 7/8	14.9
3/16	0.48	1 3/4	4.4	6	15.2
7/32	0.56	2 3/16	5.5	6 1/8	15.5
1/4	0.63	2 7/32	5.6	6 3/16	15.7
5/16	0.79	2 5/16	5.9	6 1/4	15.9
3/8	0.95	2 1/2	6.4	6 1/2	16.5
1/2	1.27	2 5/8	6.9	7 3/8	18.7
5/8	1.59	2 13/16	7.2	8	20.7
3/4	1.9	3	7.6	9 3/4	24.7
1	2.5	3 3/4	9.6	10	25.4
1 1/8	2.86	4	10.2	10 1/8	25.7
1 3/16	3.02	4 1/4	10.8	12	30.5
1 13/32	3.57	5	12.7	14	35.5
1 1/2	3.8	5 7/16	13.8	14 1/2	37
1 5/8	4.1				

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 703
October 1971
1 Page

Bureau of Materials, Testing & Research

Method of Calibration for

VOLUMETER

1. Scope

This method is intended to determine the volume of the volumeter.

2. Apparatus

2.1 Volumeter. Appropriate capacity.

2.2 Thermometer. ASTM 17 F (17 C) having a range of 66 to 80 F (19 to 27 C), graduated in 0.2 F (0.1 C) subdivisions.

2.3 Water Bath. Thermostatically controlled so as to maintain the bath at 77 F ± 0.9 F (25 C ± 0.5 C).

2.4 Balance. A balance having a capacity of 4½ Kg, sensitive to 0.1 gram.

2.5 Distilled Water. Freshly-boiled distilled water.

3. Significance

3.1 It is essential that all equipment is calibrated accurately. Exercise care in calibrating the equipment. All subsequent tests are dependent upon the calibrated equipment. It is also important to calibrate all equipment and material at the same temperature as will be used in conducting the test. All air bubbles shall be eliminated prior to weighing. All weights shall be made to the nearest tenth (0.1) of a gram. The maximum permissible variation in temperature shall not exceed ± 0.2 F (± 0.1 C) from the specified temperature.

4. Procedure

4.1 Weigh the clean dry volumeter (metal pycnometer). Fill the volumeter with freshly-boiled distilled water, cover and immerse the volumeter for one hour in a distilled water bath maintained at 77 F. Remove the cover, and eliminate any air bubbles that are present, if necessary add distilled water to fill the volumeter. Cover and make certain that the capillary tube is filled with water, wipe the volumeter dry and weigh.

5. Calculations

5.1 Calculate the volume of the volumeter as follows:

$$(WV_o + W_a) - WV_o = VV_o$$

where:

WV_o = weight of volumeter in grams,
W_a = weight of water in grams, and
VV_o = volume of volumeter in cc's.

NOTE 1–Weight of volumeter in grams plus the weight of water in grams in the volumeter, minus the weight of the volumeter in grams equals the volume of the volumeter in cc's.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 704
August 1968
1 Page

Bureau of Materials, Testing & Research

Method of Calibration for

BITUMENOMETER

1. Scope

1.1 This method is intended to determine the volume of the bitumenometer.

2. Apparatus

2.1 Bitumenometer. Minimum capacity 700 cc.

2.2 Thermometer. ASTM 17 F (17 C), having a range of 66 to 80 F (19 to 27 C), graduated in 0.2 F (0.1 C) subdivisions.

2.3 Water Bath. Thermostatically controlled so as to maintain the bath at 77 F ± 0.9 F (25 C ± 0.5 C).

2.4 Balance. A balance having a capacity of 4½ Kg, sensitive to 0.1 gram.

2.5 Distilled Water. Freshly-boiled distilled water.

3. Significance

3.1 It is important to calibrate all equipment and material at the same temperatures as will be used in conducting the test, in order to have expressions such as 77/77 F (25/25 C), and thereby eliminating unnecessary calculations. All air bubbles shall be eliminated prior to weighing. All weights shall be made to the nearest tenth (0.1) of a gram. The maximum permissible variation in temperature shall not exceed ± 0.2 F (0.1 C) from the specified temperature.

4. Procedure

4.1 Weigh the clean, dry bitumenometer. Fill the bitumenometer with freshly-boiled distilled water, insert stopper-capillary, and immerse in a water bath maintained at 77 F (25 C), for one hour. Raise the bitumenometer, making certain that capillary tube is filled to the top and that no air bubbles are present. Wipe off the top of the stopper-capillary tube and place stopper cap over the tube. Remove the bitumenometer from the water bath and wipe it dry with a dry cloth and weigh.

5. Calculations

5.1 Calculate the volume of the bitumenometer as follows:

$$(WB_r + W_a) - WB_r = VB_r$$

where:

WB_r = weight of bitumenometer in grams,
W_a = weight of water in grams,
VB_r = volume of bitumenometer in cc's.

NOTE 1--Weight of bitumenometer in grams plus the weight of water in grams in the bitumenometer, minus the weight of bitumenometer in grams equal the volume of the bitumenometer in cc's.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 705
October 1973
13 Pages

Bureau of Materials, Testing & Research

Method of Tests for

MARSHALL CRITERIA FOR COMPACTED BITUMINOUS SPECIMENS

1. Scope

1.1 This method is used for the application of Marshall design and control criteria of compacted bituminous concrete specimens prepared with asphalt cement, asphalt cutback or tar, and aggregates.

1.2 This method is a modification of ASTM D 1559. Modifications consist of the use of an automatic recording apparatus to yield a complete stress/strain diagram, use of an automatic compaction hammer instead of the manually operated hammer and more detailed specifications for the mixing and compaction temperatures. The method has been further modified to include determination of the VMA (voids in mineral aggregate), VFA (voids filled with asphalt), percent Air Voids and density of the compacted specimen. Provision has been made for use of a 6 in. diameter specimen mold.

2. Apparatus for 4 inch Diameter Specimen

2.1 Specimen Mold Assembly – 9 mold cylinders, 4 in. inside diameter by 3-7/16 in. high, equipped with base plates and extension collars, conforming with the details shown in Fig. 1.

2.2 Specimen Extractor – A specimen extractor for extracting the specimen from the mold is recommended. The specimen can be extracted from the mold with a plunger and hammer, but damage to the specimen may occur.

2.3 Mechanical Compactor and Compaction Hammer – Mechanical compactor complete with 110, 220 or 110/220 VAC 1/4 hp minimum motor, chain lift, frame, automatic hammer release, mold holder and a compaction hammer with a flat, circular tamping face, 3-7/8 in. diameter and a 10 pound sliding weight with a free fall of 18 inches.

2.4 Compaction Pedestal – The compaction pedestal shall consist of an 8 by 8 in. high wooden post capped with a 12 by 12 by 1 in. steel plate. The wooden post shall be oak, yellow pine or other wood having a dry weight of 42 to 48 lb. per cu. ft.. The post may be constructed with a solid piece of lumber or it may be laminated by gluing. The wooden post shall be secured by four angle brackets to a solid concrete slab. The steel cap shall be centrally located on the top of the post and shall be firmly fastened to the post. The pedestal assembly shall be installed so that the post is plumb and the cap is level.

2.5 Specimen Mold Holder – The specimen mold holder shall conform to the details of Fig. 2. It shall be mounted so that the circular hold-down section is located centrally over the compaction pedestal.

2.6 Breaking Head – The breaking head, conforming with the details shown in Fig. 3, consists of upper and lower circular segments, or test heads, having an inside radius of curvature of 2 in. accurately machined and plated. The lower segment shall be mounted on a base having two perpendicular guide rods or posts extending upward. Guide sleeves in the mounting plate for the upper segment shall be positioned to direct the two segments together without binding or loose motion on the guide rods.

2.7 Automatic Testing Apparatus – The Automatic testing apparatus records the stress/strain diagram and permits determination of the stability and flow of the bituminous concrete specimen. It shall have a vertically moving crosshead which moves uniformily at a rate of 2.0 in. per minute, a load cell for measurement of applied load and a means for recording and measuring the movement of the breaking heads. The equipment shall be capable of recording full scale loads of 2500, 5000 and 10,000 pounds.

2.8 Oven — A circulating air oven shall be provided for heating aggregates, bituminous materials, specimen molds and other miscellaneous equipment to the required mixing and molding temperatures. The oven shall be capable of maintaining temperatures within a range of 5 F (2.8C) up to a maximum of 350 F (176.6 C).

2.9 Water-Bath — The water bath shall be at least 6 in. (152.4 mm) deep, have sufficient inside area so that the 4 in. diameter specimens can be placed in the water with a minimum clearance of 1/2 in. (12.7 mm) on all sides, shall be thermostatically controlled to maintain the bath at 140 ± 1.8 F (60.0 ± 1.0 C) uniformly throughout the bath and shall have a perforated false bottom or be equipped with a shelf for supporting the specimens 2 in. (50.8mm) above the bottom of the bath.

2.10 Bitumenometer — A glass pycnometer of approximately 750 ml capacity. See Fig. 4, PTM 702.

2.11 Volumeter — A cylindrical metal pycnometer fitted with a cover having a concave taper on the under side and a capillary vent at the center of the cover and the taper. The fit between the upper rim of the volumeter and the underside of the flange on the cover shall be a bearing fit and no motion shall be detectable between these pieces when the outer edge of the cover is firmly pressed at various points. The volumeter shall be a nominal 4 in. (101.6 mm) deep. An inside diameter of 5-1/4 to 6-1/2 in. is suitable.

2.12 Sieve Shaker and Sieves — The sieve shaker shall be mechanically operated and the sieves shall conform to the specifications for the U.S. Standard Series (Table 1, PTM 117).

2.13 Miscellaneous Equipment

2.13.1 Pans — Flat bottom pans or other suitable containers for heating of aggregate.

2.13.2 Asphalt Containers — Gill-type metal cans, pouring pots or sauce pans may be used as containers for the asphalt when it is heated to mixing temperature in the oven.

2.13.3 Mixing Bowls — At least two hemispherical stainless steel bowls, with flat bottoms, having sufficient capacity for hand mixing of individual batches of bituminous concrete (5-12 qt. standard size approximately 5 in. deep is satisfactory).

2.13.4 Mixing Tool — A steel trowel (garden type) or spatula for mixing and spading of the bituminous mixture.

2.13.5 Hot Plates — Electric hot plates, 8 in. diameter, with low, medium and high heat control for heating apparatus and materials.

2.13.6 Thermometers — For determining temperature of aggregates, bitumen and bituminous mixtures. Range should be 50 to 500 F (10 to 260 C) with sensitivity of 5 F (3 C).

2.13.7 Thermometers — For water bath with a range of 134 to 148 F (57 to 65 C), ASTM 20 F or 20 C graduated in 0.2 F (0.1C) divisions.

2.13.8 Balance — 4-1/2 kg capacity, sensitive to 0.1 gm. Beam or dial graduated from 0 to 10 gm in 0.1 gm increments and brass weights (1.0 to 1,000 gm, Class C or better).

2.13.9 Gloves — Asbestos and rubber for protection of personnel.

2.13.10 Crayons — Lumber crayons, preferably yellow color for marking and identifying specimens.

2.13.11 Scoop — A metal scoop with a flat bottom.

2.13.12 Spoon — A large heavy duty spoon for placing mixture in specimen molds.

3. Apparatus for 6 inch Diameter Specimen

3.1 Specimen Mold Assembly — Nine (9) mold cylinders 6 in. inside diameter by 4-½ in. height, equipped with base plate and extension collars, conforming with the details of Fig. 4.

3.2 Compactor and Pedestal — The compactor and the pedestal shall conform to the specifications of Sections 2.3 and 2.4 with the exceptions that the hammer shall have a weight of 22.5 lb., the face diameter shall be 5 7/8 in. diameter and the mold hold-down shall conform to the details of Fig. 5.

3.3 Breaking Head — The breaking head shall conform with the details of Fig. 6.

3.4 Testing Apparatus — The testing apparatus shall conform to the requirements of Section 2.7.

3.5 Oven — The oven shall conform to the requirements of Section 2.8.

3.6 Water Bath – The water bath shall conform to the specifications of Section 2.9, with the exception that the bath shall be at least 9.0 in. (228.6 mm) deep.

3.7 Miscellaneous Equipment – The miscellaneous equipment, shall conform with the requirements of Section 2.11, 2.12 and 2.13 with the following exceptions: (a) The mixing bowls shall be of standard 13 qt. size and approximately 6-¼ in. deep. (b) The balance shall have a capacity of 10 kg sensitive to 0.5 gm. (c) The volumeter shall be at least 4-¼ inches deep and shall have an inside diameter 7-3/8 to 7-½ inches.

4. Test Specimens

4.1 Number of Specimens – Prepare atleast three specimens for each combination of aggregates and bitumen.

4.2 Preparation of Aggregates – Dry aggregates to a constant weight at 230 to 300 F (100 to 149 C). Separate the dried and cooled aggregate by dry sieving. The following sieve fractions are required:

Passing	Retained
No. 200	Pan
No. 100	No. 200
No. 50	No. 100
No. 30	No. 50
No. 16	No. 30
No. 8	No. 16
No. 4	No. 8
3/8"	No. 4
1/2"	3/8"
3/4"	1/2"
1"	3/4"
1-½"	1"

NOTE: Fine aggregate is sieved through the series of sieves from No. 4 through No. 200 and 1B and 2B aggregates are sieved through the series of sieves from 1-½" through the No. 8, with the minus No. 8 aggregate retained in the pan.

4.3 Mixing and Compacting Temperatures – The mixing temperature shall be the maximum temperature ± 5 F stated on the affidavit, Form 431. The compaction temperature shall be the minimum temperature ± 5 F stated on the affidavit, Form 431. As an alternative, the viscosity (Poises) at 140 F and the viscosity (cSt) at 275 F can be plotted on Form 4253, Viscosity-Temperature Chart, and connected by a straight line. The mixing temperature shall be such as to yield a viscosity of 170 + 20 cSt and the compaction temperature shall be such as to yield a viscosity of 280 ± 30 cSt. These temperatures apply only to asphalt cements. In the case of emulsions or cutbacks, the requirements of Bulletins 25 and 27 shall apply. The corresponding viscosities for tar shall be Engler Specific Viscosities of 25 ± 3 for mixing and 40 ± 5 for compacting.

4.4 Preparation of Mixtures – For each test specimen, weigh into separate pans the amount required of each aggregate size fraction to produce a batch that will result in a compacted specimen 2.5 ± 1/16" in height for four-inch diameter specimens and 3.75 ± 1/16" for six-inch diameter specimens. Place the mixing bowl, pans of aggregate and the mixing tool in an oven at the required temperature and bring to the required temperature. Weigh the required amount of asphalt (plus 5 to 10 gm to allow for bitumen which will adhere to the sides of the can) into a suitable container, such as a gill-type can, and place in the oven containing the mixing bowl, pans of aggregate and tools for a period of 30 to 45 minutes. Charge the heated mixing bowl with the heated aggregate and place on a hot plate to maintain the required temperature. Dry mix the heated aggregates thoroughly. Form a crater in the center of the mixed aggregate and weigh the required amount of asphalt into the mixing bowl. At this point, the temperature of the aggregate and bituminous material shall be within the limits of the established mixing temperature as per Section 4.3. Mix the bitumen and aggregate rapidly until thoroughly coated.

4.5 Compaction of Specimens — Heat the cleaned specimen mold assembly in an oven at 200 to 300 F (93.3 to 148.9 C) and place the compaction hammer on a hot plate for preheating. Place a piece of filter paper or paper toweling cut to size in the bottom of the mold. Place approximately one half of the batch in the mold assembly mounted on the compaction unit and spade the mixture vigorously with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior. Place the second half of the mixture in the mold assembly and repeat the foregoing procedure. Level the top of the bituminous mixture and place a piece of filter paper or paper toweling cut to size on top of the mixture. Apply 50 blows with the 10 lb. hammer for 4 in. diameter specimens and 75 blows with the 22.5 lb. hammer for 6 in. diameter specimens to the upper face of the specimen with a free fall in 18 in. (457.2 mm). Remove the extension collar and the specimen mold from the base plate, invert the specimen mold, replace the extension collar and apply the same number of blows to the other face of the specimen. Upon completion of compaction remove the extension collar and the base plate. Place the specimen mold on a firm surface and allow the specimen to cool to room temperature. When the specimen reaches room temperature, place the specimen mold assembly in the specimen extractor and mechanically force the specimen from the mold. The specimen may be removed with a plunger and a hammer, but damage to the specimen is apt to occur. Carefully transfer the specimen to a smooth, flat surface and allow it to stand overnight at room temperature.

5. Testing of Compacted Marshall Specimens

5.1 Calculations — The Department of Transportation Form TR-4265, Marshall Specimen Work Sheet, is used for the calculation of the VMA, VFA, Density and Percent Air Voids of the specimen. These calculations must be performed before the compacted specimen is destroyed by determination of stability and flow of the specimen. The actual sequence of calculations is as follows:

1) Enter the Sample No., Bituminous Concrete Specifications, Type of Aggregate and the Height of the specimen (to the nearest 1/16 in.) on the Work Sheet.

2) Weigh the sample plus water required to fill the volumeter. Use of a tare weight for the weight of the dry and empty volumeter will permit direct determination of these values.

3) Calculate the volume of water in the volumeter.

4) Enter calibrated volume of volumeter (PTM 703) and subtract the volume of water in the volumeter with the sample to obtain the volume of the sample.

5) Weight of the sample divided by the volume of the sample yields the Specific Gravity of the sample or its Density in gm/cc. Refer to PTM's 714, 715 and 716.

6) Divide the weight of the sample by the Maximum Theoretical Specific Gravity (PTM's 711 or 740 whichever applicable) to obtain the Theoretical Volume of the specimen.

7) Actual volume of the sample (Step 4) minus the calculated theoretical volume of the specimen equals the volume of air voids (in ml) in the specimen. This value divided by the volume of the specimen and multiplied by 100 gives the Percent Air Voids in the specimen.

8) Weight of the specimen multiplied by the percent asphalt in the specimen gives the weight of the asphalt in the specimen. Dividing this value by the Sp. Gr. of the asphalt at 77 F yields the volume of asphalt in the specimen.

9) Volume of the asphalt plus the volume of the air voids gives the volume of the VMA. This value divided by the volume of the sample and multiplied by 100 gives the Percent VMA in the specimen.

10) Volume of asphalt in the specimen divided by the Volume of VMA multiplied by 100 gives the Percent VFA in the specimen.

11) Blot the water-wet specimen with absorbent paper or cloth toweling and weigh to 0.1 gm.

12) The difference between the damp dry weight and the dry weight gives the weight of water absorbed by the specimen.

13) The weight of the water absorbed divided by the dry weight of the specimen and multiplied by 100 gives the Percent Water Absorption (by weight).

5.2 Determination of Stability and Flow

5.2.1 Bring the specimen to test temperature by immersion in the water bath for 45 minutes at the required temperature. Thoroughly clean the guide rods and the inside of the breaking head. Heat the test heads to 100 to 110 F (37.8 to 43.3 C) by immersion in the water bath. Remove the specimen from the water bath and place in the lower segment of the breaking head. Place the upper segment of the breaking head on the specimen and locate the assembly in position on the testing machine so that the center of the breaking head is directly under the load button of the testing machine.

5.2.2 Place a sheet of the standard Marshall graph paper or a roll of similar paper on the tester, lower the pen and adjust to zero. For detailed description of the operation of automatic recording testers refer to PTM's 723, 724 and 728.

5.2.3 Additional specimens may be tested and recorded on the same Marshall chart, especially if the tester is adaptable to the use of multi-colored felt tip pens.

5.2.4 The elapsed time from removal of the specimen from the water bath to completion of the test shall not exceed 30 seconds.

5.2.5 The report shall include the following information for each specimen tested. These data shall be recorded on the Marshall chart and include firm indentification of the data for each specimen.

5.2.5.1 Height of the specimen to the nearest 1/16 in.

5.2.5.2 Corrected maximum load in pounds (see Table No. 1). It is desirable that the chart load in pounds and the correction factor be shown on the chart as verification of the corrected maximum load.

5.2.5.3 Flow value, in hundreths of an inch, measured at the initial point of maximum load. When the load produces a "flat" at the maximum, the flow is read at the initial point and it is NOT reported as an average of the minimum and maximum flow.

5.2.5.4 Mixing Temperature

5.2.5.5 Compacting Temperature

5.2.5.6 Test Temperature

6. Reference

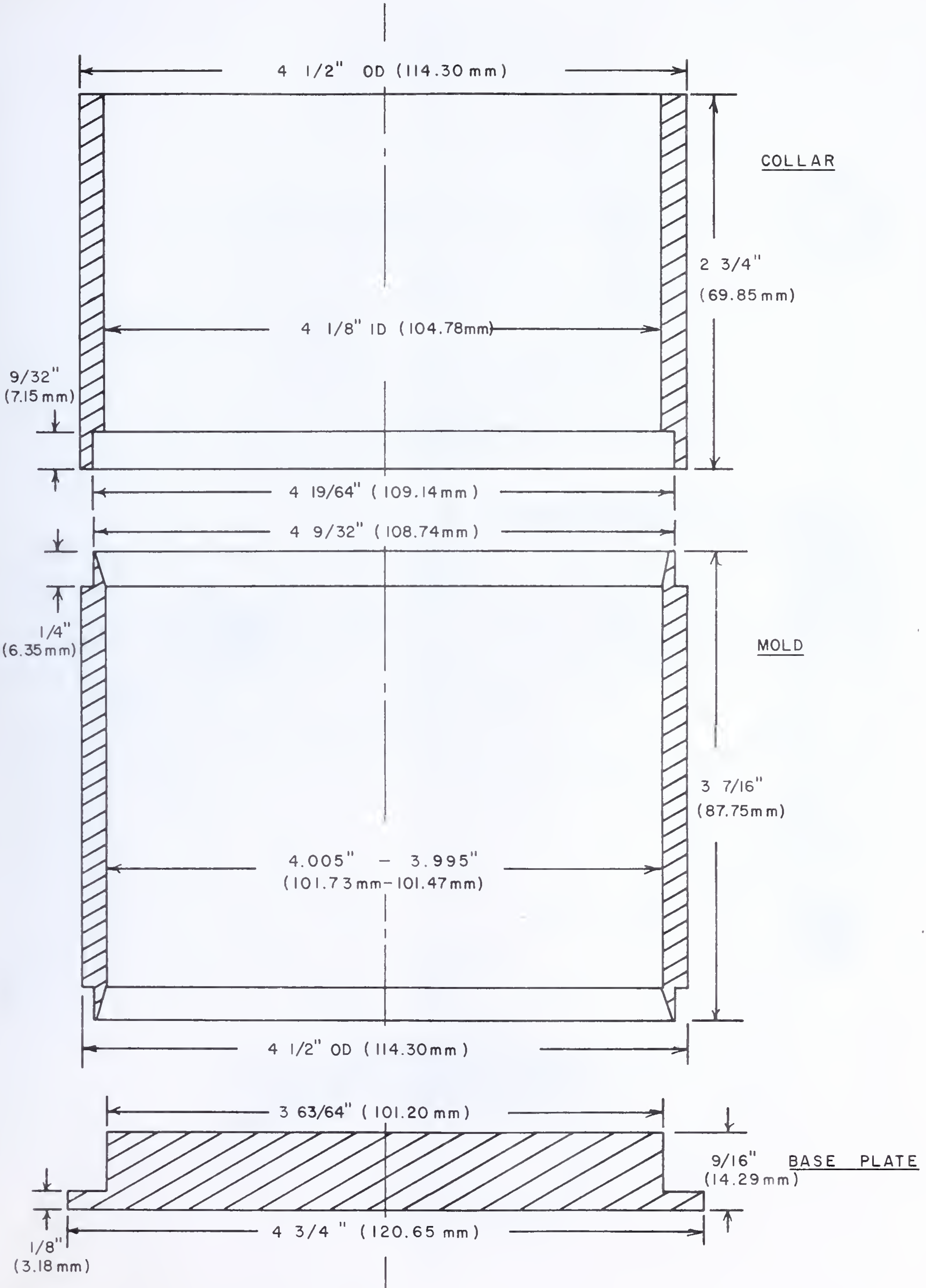
ASTM D 1559

Table 1.

STABILITY CORRELATION RATIO

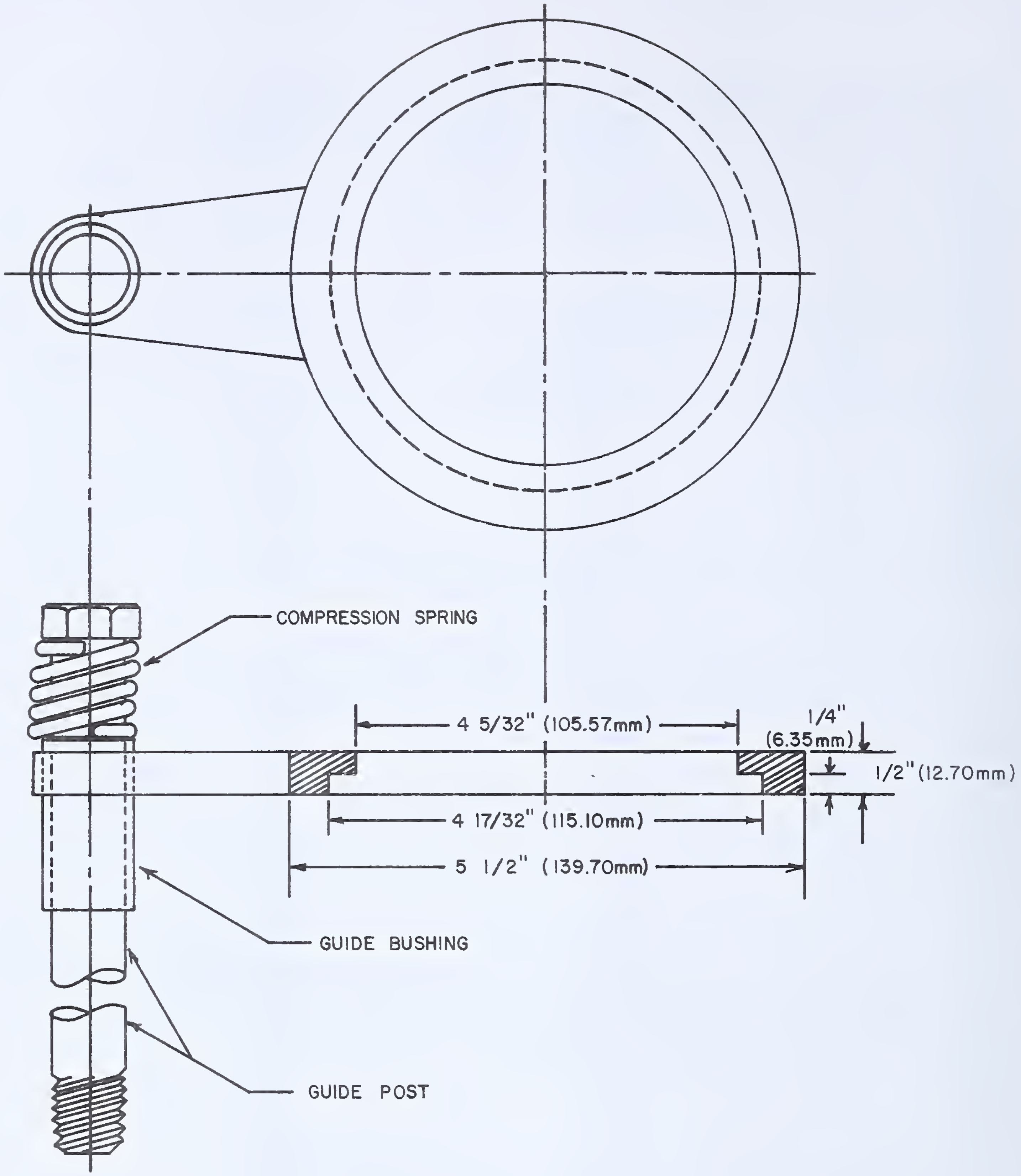
4 in. Diameter Specimens		6 in. Diameter Specimens	
Specimen Height Inches	Correlation Ration	Specimen Height Inches	Correlation Ratio
2 1/4	1.19	3 1/2	1.12
2 5/16	1.14	3 9/16	1.09
2 3/8	1.09	3 5/8	1.06
2 7/16	1.04	3 11/16	1.03
2 1/2	1.00	3 3/4	1.00
2 9/16	0.96	3 13/16	0.97
2 5/8	0.93	3 7/8	0.95
2 11/16	0.89	3 15/16	0.92
2 3/4	0.86	4	0.90

NOTE: Recorded stability for each specimen shall be multiplied by the appropriate correlation ratio for the specimen height to convert the stability value to that of a specimen of standard height.



4 INCH COMPACTION MOLD

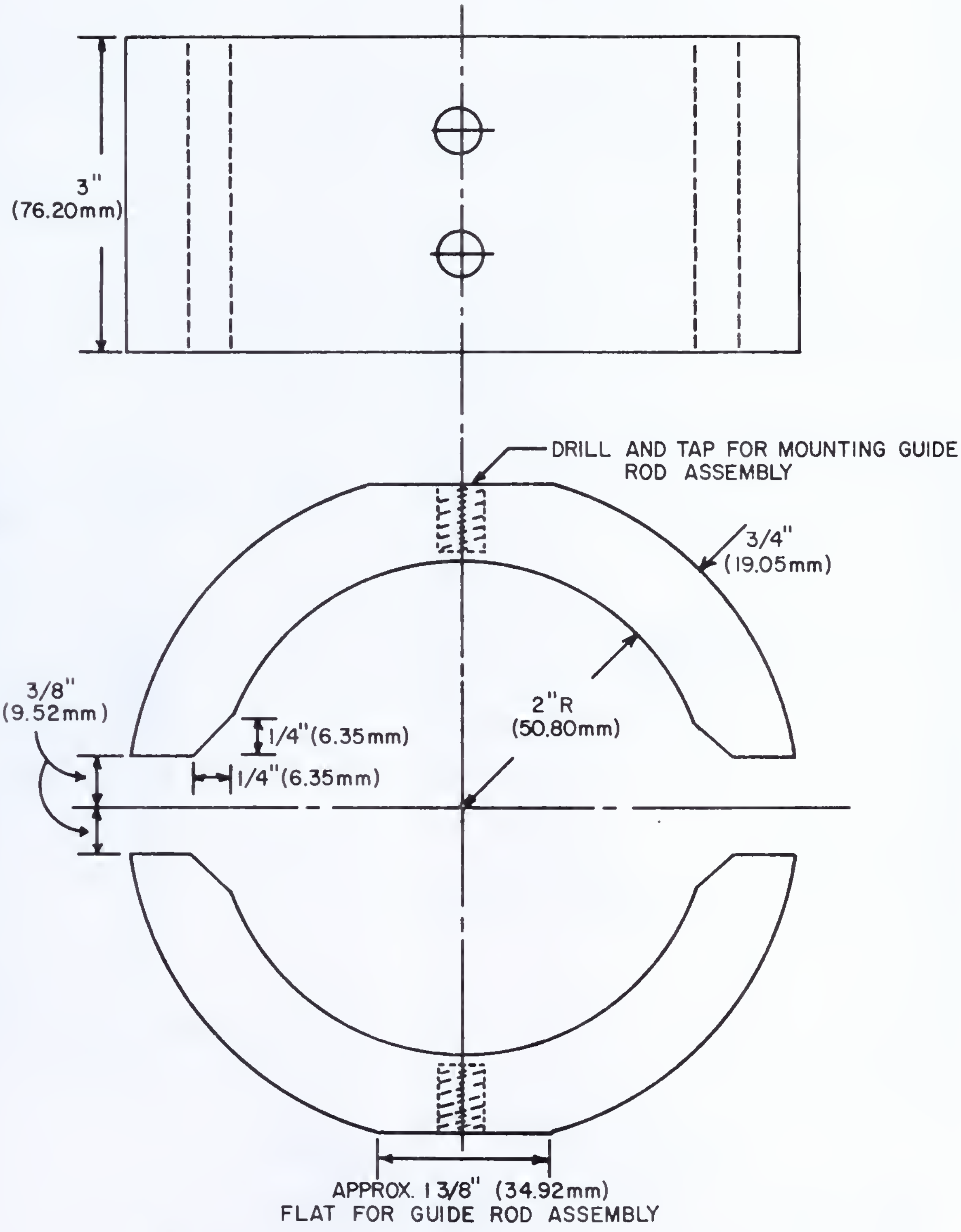
FIG. 1



NOTE: GUIDE POST THREADED INTO PEDESTAL CAP. DIMENSIONS OF GUIDE POST, GUIDE BUSHING AND COMPRESSION SPRING NOT CRITICAL. ONLY REQUIREMENT IS THAT COMPACTION MOLD IS HELD FIRMLY.

4 INCH SPECIMEN MOLD HOLDER

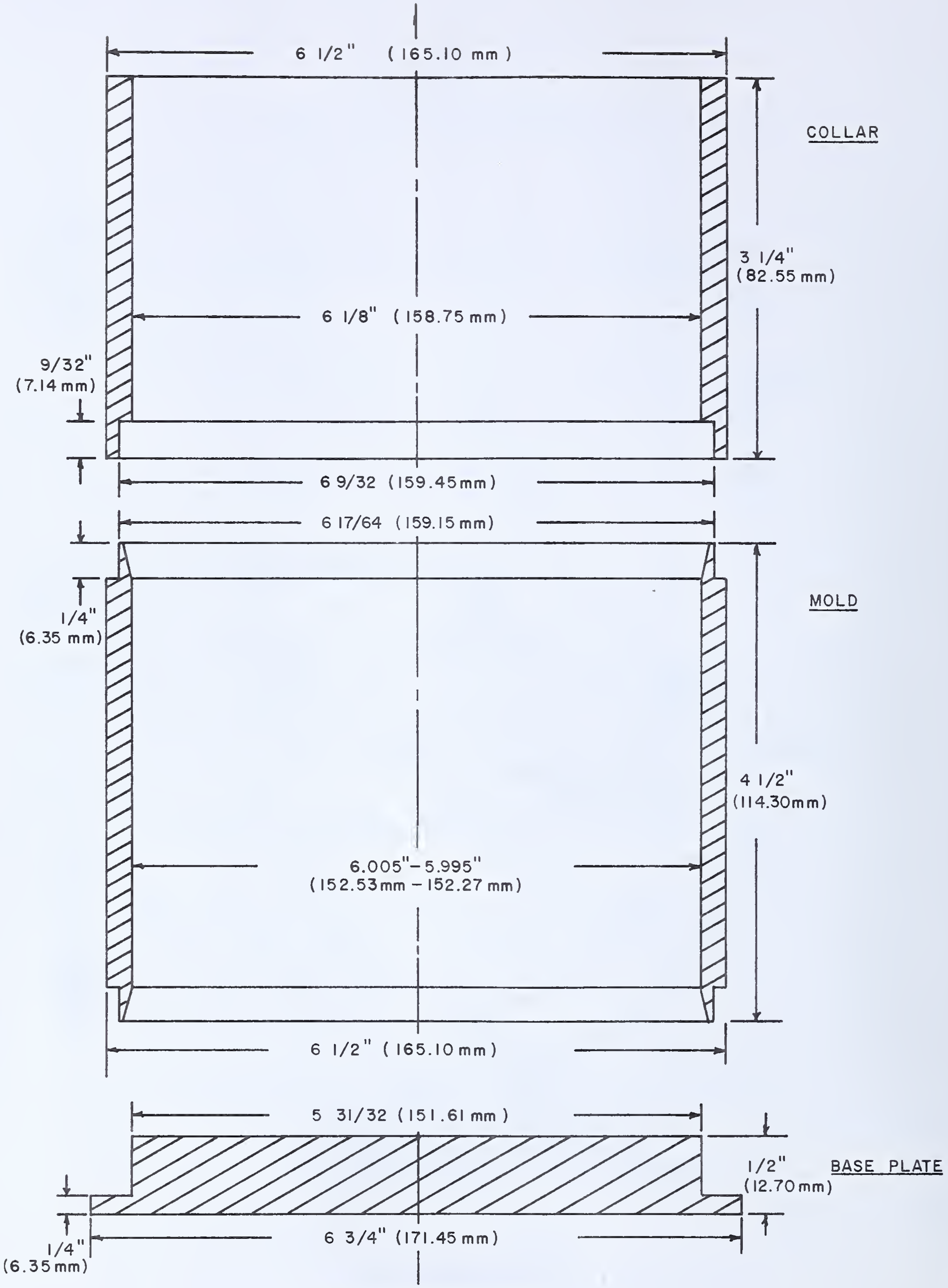
FIG. 2



MATERIAL: CHROME OR CADMIUM PLATED STEEL

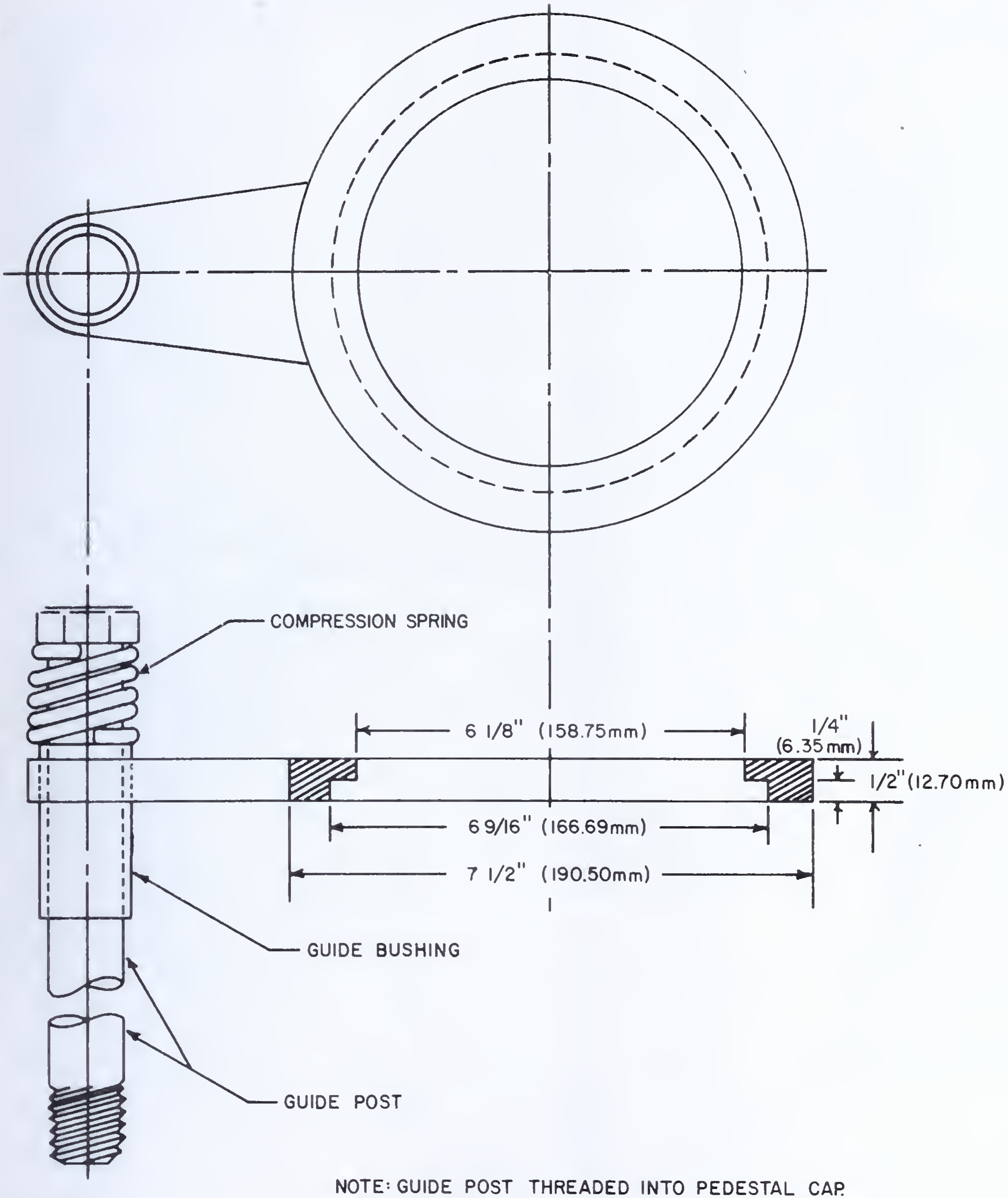
4 INCH COMPRESSION RING

FIG. 3



6 INCH COMPACTION MOLD

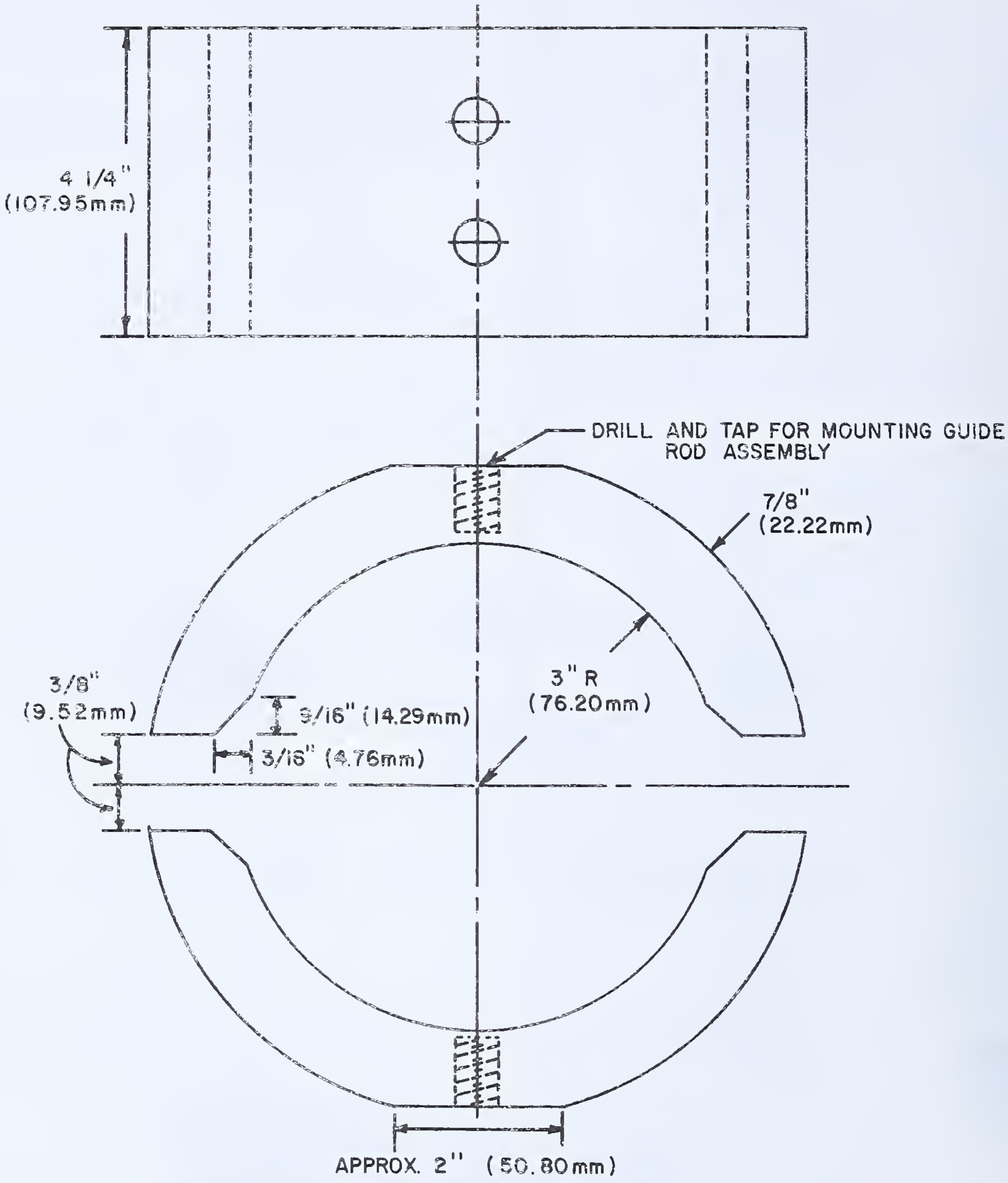
FIG. 4



NOTE: GUIDE POST THREADED INTO PEDESTAL CAP. DIMENSIONS OF GUIDE POST, GUIDE BUSHING AND COMPRESSION SPRING NOT CRITICAL. ONLY REQUIREMENT IS THAT COMPACTION MOLD IS HELD FIRMLY.

6 INCH SPECIMEN MOLD HOLDER

FIG. 5



MATERIAL: CHROME OR CADMIUM PLATED STEEL

6 INCH COMPRESSION RING

FIG. 6

TR-4265 (3-71)
CC-0839-4200-0970

MARSHALL SPECIMEN WORK SHEET

SAMPLE No.						
SPECIF.						
AGG.						
HEIGHT						
WT SAMP + H_2O						
— WT SAMP						
= VOL WATER						
VOL VOLUMETER						
— VOL WATER						
= VOL SAMPLE						
WT SAMPLE						
÷ VOL SAMPLE						
= SP GR SAMPLE						
WT SAMPLE						
+ THEOR. SP GR						
= THEOR. VOL.						
VOL. SAMPLE						
— THEOR. VOL.						
= VOL. VOIDS						
÷ VOL. SAMPLE						
= % VOIDS						
WT SAMPLE						
x % ASPHALT						
= WT ASPHALT						
÷ SP GR A.C.						
= VOL. A.C.						
+ VOL. VOIDS						
= VOL. V.M.A.						
+ VOL. SAMPLE						
= % V.M.A.						
VOL. ASPHALT						
÷ VOL. V.M.A.						
= % V.F.A.						
DAMP DRY WT						
— DRY WT						
= WT ABSORB.						
÷ DRY WT						
= % ABSORB.						
STABILITY						
FLOW						
AVG. STAB.						
AVG. FLOW						

REMARKS

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 706
August 1968
1 Page

Bureau of Materials, Testing & Research

Method of Test for

DETERMINATION OF SPECIFIC GRAVITY OF SOLVENTS

1. Scope

1.1 This method of test is intended for determination of the specific gravity of a solvent.

2. Apparatus

2.1 Bitumenometer. Any capacity.

2.2 Thermometer. ASTM 17 F.(17 C.) having a range of 66 to 80 F. (19 to 27 C.), graduated in 0.2 F. (0.1 C.) subdivisions.

2.3 Water Bath. Thermostatically controlled so as to maintain the bath at 77.0 F ± 0.9 F. (25 C. ± 0.5 C.).

2.4 Balance. A balance having a capacity of 4 1/2 kg., sensitive to 0.1 gram.

3. Test Sample

3.1 Solvent intended for use in extraction of bituminous mixtures.

4. Procedure

4.1 Fill a calibrated bitumenometer with solvent 60 to 77 F (20 to 25 C), insert capillary tube and immerse in a water bath (to about the 7/8 mark of the bitumenometer) maintained at 77.0 F. for one hour. At the end of the one hour period, slightly raise the bitumenometer, check the temperature, and make certain that the stopper-capillary tube is filled to the top with solvent and that no air bubbles are present. Remove the excess solvent from the top of the tube and place the overflow cap on the stopper-capillary tube.

4.2 Remove the bitumenometer from the water bath and wipe it dry with a dry absorbent cloth. Weigh the bitumenometer and solvent to the nearest tenth (0.1) of a gram.

5. Calculations

5.1 Calculate the specific gravity of the solvent as follows:

Let:
VBr = Volume in cc of bitumenometer at 77.0 F.
WS = Weight in grams solvent in the bitumenometer @ 77.0 F.
GS = Specific gravity of solvent @ 77.0 F.
Then:

$$\frac{WS}{VBr} = GS$$

NOTE 1. The specific gravity of the solvent enters into many calculations, therefore, it is important that the specific gravity of the solvent be determined within 0.001 value.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 707
June, 1975
1 Page

Bureau of Materials, Testing & Research

Method of Test for

DETERMINATION OF SPECIFIC GRAVITY OF AGGREGATES IN WATER USING THE BITUMENOMETER

1. Scope

1.1 This method is intended for the determination of the specific gravity of aggregates in water using the bitumenometer and is a modification of AASHO T 100-

2. Apparatus

2.1 Balance. A balance having a capacity of 4½ Kg, sensitive to 0.1 gram.

2.2 Water Bath. Thermostatically controlled to maintain the bath at 77 F ± 0.9 F (25 C ± 0.5 C).

2.3 Thermometer. ASTM 17 F (17 C), having a range of 66 to 80 F (19 to 27 C), graduated in 0.2 F (0.1 C) subdivisions.

2.4 Bitumenometer. Appropriate capacity.

3. Test Samples

3.1 Aggregates to be used in the bituminous mixtures. Aggregates should be dried to constant weight in a suitable oven.

4. Procedure

4.1 In a dry calibrated bitumenometer, accurately weigh to the nearest tenth (0.1) of a gram, a 200 to 500 gram sample. Place the bitumenometer and contents in a water bath, (to about the 7/8 mark of the bitumenometer) maintained at 77 F for one hour.

4.2 Remove and fill bitumenometer rapidly as possible with distilled water at 77 F. Insert stopper-capillary tube and make certain that capillary tube is filled to the top with distilled water and that no air bubbles are present. Agitate the contents and tilt bitumenometer to 45° angle and give 4 complete rolls to eliminate air bubbles. Wipe the top of the stopper-capillary tube and place the overflow cap over the tube. Remove and wipe it dry with a dry absorbent cloth and weigh.

5. Calculations

5.1 Calculate the specific gravity of the aggregates as follows:

$$\mathrm{GSm} = \frac{\mathrm{WSm}}{\mathrm{VBr} - (\mathrm{WSm} + \mathrm{WWa} - \mathrm{WSm})}$$

where:

VBr = volume in cc of bitumenometer @ 77 F,
WSm = weight in grams of sample in bitumenometer @ 77 F,
WSm + WWa = weight in grams of sample and water in bitumenometer @ 77 F, and
GSm = specific gravity of sample @ 77 F.

6. References

AASHO T 100-
ASTM D 254-

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 708
October 1971
1 Page

Bureau of Materials, Testing & Research
Method of Test for

DETERMINATION OF SPECIFIC GRAVITY OF BITUMEN IN WATER

1. Scope

1.1 This method of test is intended for the determination of the specific gravity of bitumen in water, and is a modification of AASHO T228- .

2. Apparatus

2.1 Balance. A balance having a capacity of 4 1/2 kg., sensitive to 0.1 Gram.
2.2 Water Bath. Thermostatically controlled to maintain the bath at 77 F ± 0.9 F. (25 C. ± 0.5 C.)
2.3 Thermometer. ASTM 17 F (17 C.) having a range of 66 to 80 F. (19 to 27 C.) graduated in 0.2 F. (0.1 C) subdivisions.
2.4 Bitumenometer. Any capacity.

3. Test Samples

3.1 Bitumen to be used in bituminous mixtures.

4. Procedure

4.1 In a dry calibrated bitumenometer, accurately weigh to the nearest tenth (0.1) of a gram, a 200 to 500 gram sample. Cool to room temperature and fill the bitumenometer with freshly-boiled distilled water (70 to 76 F.), insert stopper-capillary tube and place the bitumenometer and contents (to about the 7/8 mark of the bitumenometer) in a water maintained at 77.0 F. for one hour.

4.2 Raise bitumenometer, check the temperature and make certain that the capillary tube is filled to the top with water and that no air bubbles are present. Wipe off the top of the tube and place the overflow cap over the tube.

4.3 Remove the bitumenometer from the water bath and wipe it dry with a dry absorbent cloth. Weigh.

5. Calculations

5.1 Calculate the specific gravity of bitumen as follows:

Let:

VBr = Volume in cc of bitumenometer at 77.0 F.
WSm = Weight in grams of sample in bitumenometer at 77.0 F.
WSm + WWa = Weight in grams of sample and water in bitumenometer at 77.0 F.
GSm = Specific gravity of sample at 77.0 F.

Then

$$\frac{WSm}{VBr - / \ (WSm + WWa) - WSm \ /} = GSm$$

6. Reference:

AASHO T 228-

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 711
June, 1975
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

THEORETICAL SPECIFIC GRAVITY BASED ON THE INDIVIDUAL CONSTITUENTS

1. Scope

1.1 This method computes the theoretical specific gracity by using the individual specific gravities of the ingredients in the mix. This method shall be employed when water absorption of the coarse aggregate in the mix is less than 2.0 percent. For highly absorptive coarse aggregates (water absorption 2.0 percent or more), PTM No. 740 shall be used.

2. Apparatus

2.1 Balance. A balance having a capacity of 4½ Kg, sensitive to 0.1 gram.

2.2 Water Bath. Thermostatically controlled to maintain the bath at 77 F ± 0.9 F (25 C ± 0.5 C).

2.3 Thermometer. ASTM 17 F (17 C), having a range of 66 to 80 F (19 to 27 C), graduated in 0.2 F (0.1 C) subdivisions.

2.4 Bitumenometer or Volumeter. Appropriate capacity.

3. Test Samples

3.1 Ingredients that will be used in the bituminous concrete mixtures.

4. Procedure

4.1 Determine the specific gravity of the constituents to be used in the bituminous mixture. (PTM 707- , 708-).

4.2 Set up the formula for each constituent on a percent by weight basis.

4.3 Determine the volume of each constituent by dividing the percent by weight of the constituent by the specific gravity.

4.4 Add the volumes of the constituents to obtain the volume of the mix.

4.5 Divide the total volume of the mix into 100 to obtain the theoretical specific gravity of the mix.

5. Calculations

5.1 Mixes vary in the number of constituents. An example is given where four constituents comprise the mix. Calculate the theoretical specific gravity as follows:

$$T = \frac{100}{\frac{W}{G} + \frac{W-1}{G-1} + \frac{W-2}{G-2} + \frac{W-3}{G-3}}$$

where:

W = asphalt, percent by weight,
W–1 = aggregate No. 1, percent by weight,
W–2 = aggregate No. 2, percent by weight,
W–3 = aggregate No. 3, percent by weight,
G = specific gravity of asphalt cement,
G–1 = specific gravity of aggregate No. 1,
G–2 = specific gravity of aggregate No. 2,
G–3 = specific gravity of aggregate No. 3,
T = theoretical specific gravity,
100 = total 100 percent, by weight.

To obtain the percent by volume on a 100 percent basis, divide the volume of each constituent by the total volume of the mix.

Example:

$$\text{Percent By Volume Asphalt} = \frac{W/G}{\frac{W}{G} + \frac{W-1}{G-1} + \frac{W-2}{G-2} + \frac{W-3}{G-3}}$$

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 715
October, 1976
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

DETERMINATION OF BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES THAT ABSORB LESS THAN 2 PERCENT WATER BY VOLUME

1. Scope

1.1 This method of test is intended for determining the bulk specific gravity of laboratory compacted bituminous mixtures (Marshall specimens) or bituminous roadway samples, such as, cores, small sawed slabs, density ring samples etc. This method should not be used if the samples contain open or interconnecting voids. For such samples PTM No. 716 should be used.

2. Apparatus

2.1 Balance. A balance having a capacity of 4½ Kg, sensitive to 0.1 gram.

2.2 Water Bath. Thermostatically controlled so as to maintain the bath at 77± 0.9 F (25± 0.5 C).

2.3 Thermometer. ASTM 17 F (17C), having a range of 66 to 80 F (19 to 27 C), graduated in 0.2 F (0.1 C) subdivisions.

2.4 Volumeter. Calibrated to 1200 ml or appropriate capacity depending upon the size of test sample.

3. Test Specimen

3.1 Compacted specimens in accordance with PDT Methods or obtained in accordance with PDT methods of sampling of compacted roadway.

3.2 Size of specimens: It is recommended, (1) that the diameter of cylindrically molded or cored specimens, or the length of the sides of the sawed specimens, be at least equal to four times the maximum size of the aggregate; and (2) that the thickness of specimens be at least one and one half times the maximum size of the aggregate.

3.3 Specimens shall be free from foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.

3.4 If desired, specimens may be separated from other pavement layers by sawing or other suitable means.

4. Procedure

4.1 Dry the specimen to constant weight (see Note 1). Weigh the dry specimen to the nearest 0.1 of a gram. Immerse in water bath and let saturate for at least 10 minutes. At the end of the 10 minute period, fill a calibrated volumeter with distilled water at 77 F (25 C). Remove the immersed and saturated specimen from the water bath, quickly damp dry the saturated specimen with a dry absorbent cloth and as quickly as possible weigh the specimen. Any water which seeps from the specimen during the weighing operation is considered as a part of the saturated specimen.

NOTE 1 – Constant weight shall be defined as the weight at which further drying at 140± 9 F (60± 5 C) does not alter the weight 0.1 percent of the test load. Samples saturated with water shall initially be dried overnight at 140± 9 F (60± 5 C) and then weighed at two hours drying intervals. Laboratory compacted specimens and density ring samples need not be dried.

4.2 Place the weighed saturated specimen into the volumeter and let stand for at least one minute. Bring the temperature of the water to 77 F (25 C), and cover the volumeter making certain that some water escapes through the capillary bore of the tapered lid. Wipe the volumeter dry with a dry absorbent cloth and weigh the volumeter and contents to the nearest tenth (0.1) of a gram.

5. Calculations

5.1 Calculate the bulk specific gravity (on dry basis) of sample as follows (report the value up to three decimal places):

$$GSm = \frac{WSm}{VV_o - [(WSa + WWa) - WSa]}$$

where:

GSm = bulk specific gravity of specimen @ 77 F,
WSm = weight in grams of dry specimen,
VVo = volume in CC of volumeter @ 77 F to the nearest tenth of a cubic centimeter,
WSa + WWa = weight in grams of saturated specimen and water in the volumeter @ 77 F,
WSa = weight in grams of saturated specimen.

NOTE 2 — The weight of specimen and water in the above formula does not include the weight of the volumeter. The use of a tare weight for the volumeter is recommended.

NOTE 3 — For routine tests to determine degree of pavement compaction, when moisture content of the specimen is so low that it is not a significant factor, air-dry weight of the specimens may be used in place of oven-dry weight.

5.2 Calculate the percent water absorbed by the specimen (on volume basis) as follows:

$$\text{Percent Water Absorbed by Volume} = \frac{WSa - WSm}{VVo - [(WSa + WWa) - WSa)}$$

If the percent water absorbed (on volume basis) is more than 2 percent, use PTM No. 716.

6. Rapid Method for Saturated Specimens

6.1 This procedure can be used for testing specimens which are not required to be saved and which contain substantial amount of moisture. Specimens obtained by coring or sawing can be tested the same day by this method. The testing procedure shall be same as given in Section 4 except the sequence of operations. First, the weight of the saturated damp dry specimen shall be taken. Then the volumeter containing the saturated specimen and water shall be weighed. The dry weight of the specimen shall be determined last. Put the saturated specimen in a tared pan and warm in oven at 325 F (163 C) until it can be broken easily. Use care not to lose any part of the sample while breaking. Spread the broken sample in the pan and place in oven for accelerated drying to constant weight. Weigh the sample frequently to check if it has dried to constant weight.

6.2 Calculate the bulk specific gravity of sample by the formula given in Section 5.1. Calculate the percent water absorbed (on volume basis) by the formula given in Section 5.2.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 716
February 1976
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

DETERMINATION OF BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES THAT ABSORB MORE THAN 2 PERCENT OF WATER BY VOLUME

1. Scope

1.1 This method of test is intended for determining the bulk specific gravity of the laboratory compacted bituminous mixtures or bituminous roadway samples that contain open or interconnecting voids and/or absorb more than two percent of water by volume.

2. Apparatus

2.1 Balance. A balance having a capacity of 4½ Kg. sensitive to 0.1 gram.

2.2 Water Bath. Thermostatically controlled, so as to maintain the bath at 77± 0.9 F (25± 0.5 C).

2.3 Thermometer. ASTM 17 F (17 C), having a range of 66 to 80 F (19 to 27 C), graduated in 0.2 F (0.1 C) subdivisions.

2.4 Volumeter. Calibrated to 1200 ml or appropriate capacity depending on the size of the test sample.

3. Test Specimen

3.1 Specimen compacted in accordance with PDT Methods or obtained in accordance with PDT methods of sampling of compacted roadway.

4. Procedure

4.1 Dry the specimen to constant weight (see Note 1) and weigh it to the nearest tenth (0.1) of a gram.

NOTE 1 – Constant weight shall be defined as the weight at which further drying at 140± 9 F (60± 5 C) does not alter the weight 0.1 percent of the test load.

4.2 Coat the specimen with melted paraffin sufficiently thick to seal all surface voids. Allow the coating to cool in air at room temperature for 30 minutes, and then weigh the specimen to the nearest tenth (0.1) of a gram.

NOTE 2 – If it is desired to utilize the specimen for further tests which require the removal of the paraffin coating, the specimen may be dusted with powdered talc prior to coating.

NOTE 3 – Application of the paraffin may be accomplished by chilling the specimen in a refrigerating unit to a temperature of approximately 40 F (4.5 C) for 30 min. and then dipping the specimen in warm paraffin (10 F or 5.5 C above melting point). It may be necessary to brush the surface of the paraffin with added hot paraffin in order to fill any pinpoint holes.

4.3 Fill a calibrated volumeter with distilled water at 77 F (25 C). Place the coated specimen into the volumeter and cover the volumeter making certain that some water escapes through the capillary bore in the tapered lid. Wipe the volumeter dry with a dry absorbent cloth and weigh the volumeter and its contents to the nearest tenth (0.1) of a gram.

4.4 Determine the specific gravity of the paraffin @ 77± 2 F (25± 1 C), if unknown, using the bitumenometer method, as is used for determing the specific gravity of bitumen (PTM No. 708).

5. Calculations

5.1 Calculate as follows:

$$\mathrm{GSm} = \frac{\mathrm{WSm}}{\mathrm{VVo} - [(\mathrm{PWSm} + \mathrm{WWa}) - \mathrm{PWSm} + \left(\frac{\mathrm{PWSm} - \mathrm{WSm}}{\mathrm{GP}}\right)]}$$

where:

GSm = specific gravity of specimen @ 77 F,
WSm = weight in grams of uncoated specimen in air @ 77 F,
VVo = volume in cc of volumeter @ 77 F,
PWSm = weight in grams of paraffin coated specimen in air @ 77 F,
PWSm + WWa = weight in grams of paraffin coated specimen and water in volumeter @ 77 F, and
GP = specific gravity of paraffin @ 77 F.

5.2 Report the bulk specific gravity value up to three decimal places.

NOTE 4 — The weight of specimen and water in the above formula does not include the weight of the volumeter. The use of a tare weight for the volumeter is recommended.

NOTE 5 — For routine tests to determine the degree of pavement compaction when moisture content of the specimens is so low that it is not a significant factor, air-dry weight of the specimens may be used in place of oven-dry weight.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 722
January 1975
1 Page

Bureau of Materials, Testing & Research

Method of Test for

DETERMINATION OF SPECIFIC GRAVITY OF AGGREGATES IN WATER USING THE VOLUMETER

1. Scope

1.1 This method of test is intended to determine the specific gravity of aggregates in water using a volumeter.

2. Apparatus

2.1 Balance. A balance having a capacity of 4½ Kg, sensitive to 0.1 gram.

2.2 Water Bath. Thermostatically controlled to maintain the bath at 77 F ± 0.9 F (25 C ± 0.5 C).

2.3 Thermometer. ASTM 17 F (17 C), having a range of 66 to 80 F (19 to 27 C), graduated in 0.2 F (0.1 C) subdivisions.

2.4 Volumeter. Any capacity.

3. Test Specimens

3.1 Aggregate to be used in bituminous mixtures.

4. Procedure

4.1 In a dry, calibrated volumeter, accurately weigh to the nearest tenth (0.1) of a gram a 500 to 800 gram sample. Place the volumeter and contents (to about the 7/8 mark) in a water bath maintained at 77 F (25 C) for one hour.

4.2 Remove and fill the volumeter rapidly as possible with distilled water (77 F). Cover the volumeter making certain some water escapes through the capillary bore in the tapered lid. Dry the volumeter with a dry absorbent cloth and weigh the volumeter and contents to the nearest tenth (0.1) of a gram.

5. Calculations

5.1 Calculate the specific gravity of the aggregates as follows:

$$\mathrm{GSm} = \frac{\mathrm{WSm}}{\mathrm{VVo} - [(\mathrm{WSm} + \mathrm{WWa}) - \mathrm{WSm}]}$$

where:

VVo = volume in cc of volumeter @ 77 F,
WSm = weight in grams of sample in volumeter @ 77 F,
WSm + WWa = weight in grams of sample and water in volumeter @ 77 F, and
GSm = specific gravity of sample @ 77 F.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 723
August 1968
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

OPERATION OF AN AUTOMATIC MECHANICAL RECORDING TESTER (TYPE 1) FOR USE IN THE PDH DESIGN & CONTROL METHODS

1. Scope

1.1 This method covers the measurement of the resistance to plastic flow of cylindrical specimens of bituminous paving mixtures loaded on the lateral surface by means of the SATEC Automatic Bituminous Recording Tester.

2. Apparatus

2.1 Bituminous Tester. The bituminous tester shall be an Automatic Mechanical Recording Tester. The tester shall provide a uniform upward movement at the rate of 2 in. per minute and shall be capable of loading the specimen over the ranges of 0 to 2500 pounds and 0 to 5000 pounds. (Later models of 10,000 pounds).

2.2 Breaking Head. The breaking head shall consist of upper and lower cylindrical segments or test heads having an inside radius of curvature of 2 in. or 3 in. accurately machined and conforming to the dimensions of Fig. 3 and 6, respectively of PTM 705- . The lower segment shall be mounted on a base having two perpendicular guide rods or posts extending upward. Guide sleeves in the mount for the upper segment shall be in such a position as to direct the two segments together without appreciable binding or loose motion on the guide rods.

2.3 Water Bath. The water bath shall be at least 6 in. deep and shall be thermostatically controlled so as to maintain the bath at 140 ± 1.8 F (60 ± 1.0 C). A motor driven propeller type agitator shall be provided to insure adequate mixing and circulation of the water. The tank shall have a perforated bottom or be equipped with a shelf for supporting specimens 2 in. above the bottom of the bath.

2.4 Recorder Charts. Recorder charts having an ordinate scale of 0 to 2500 pounds and 0 to 5000 pounds and an abscissa scale for both charts of 0 to 35 flow units shall be provided for recording the stability and flow characteristics of the specimens.

2.5 Gloves. Long rubber gloves are required to protect the operator when inserting or removing specimens from the water bath.

3. Procedure

3.1 Heating of Specimens. The bituminous paving material specimens prepared according to the PDT Design and Control Method shall be placed in the water bath in such a position that they are submerged completely and that the specimens do not touch each other. The specimens shall be heated for not less than 45 minutes nor more than 60 minutes.

3.2 Recorder Chart. A recorder chart having an ordinate scale corresponding to the maximum load setting of the machine shall be placed on the platen so that the ordinate scale is horizontal and the point of the recorder pen is touching the corner of the chart at zero load and zero flow.

3.3 Load Setting. The load range of the machine is set by the position of a weight on a pendulum arm. This weight is accessible through a small door at the right rear of the unit. A large knurled hand screw locks the weight to the pendulum. Loosen the screw and raise the weight to the extreme upper position on the pendulum to set the load range for a maximum of 2500 pounds. Secure the weight in this position by tightening the hand screw. Loosen the weight and carefully move it to the extreme lower position on the pendulum to set the load range for a maximum of 5000 pounds. For 10,000 pounds, remove weight from the pendulum and replace with required weight in lower position. Tighten the hand screw when the weight is in position.

3.4 Testing. Check the spirit level on the machine and adjust the screw legs if the machine is not level. It is essential that the machine is level. Heat the testing head between 100 to 110 F (37.8 to 43.3 C) prior to making first test. Remove the heated breaking head from the water bath and place it in front of the machine after separating the two portions of the head. Remove a specimen from the water bath and place it centrally on the lower segment. Place the upper segment in position over the guide rods and the specimen. Place the assembly on the lower platen of the machine against the location pins so that the breaking head is centered under the pressure sensor in the upper part of the machine. The testing machine may be operated under automatic or manual control, the master switch is placed in the "AUTO" position and the "UP" button is pressed to start the machine. The test will continue until the platform has reached the uppermost position. When the tester has stopped, press the "DOWN" button. The platform will continue down until the normal position is reached. To reverse direction of platform travel press the red "STOP" button, wait until the motor has stopped, and then press the button for the desired direction. To operate the tester manually set the master switch on "MANUAL". With the specimen in position and test ready to start, press the "UP" button and hold in until test is completed or until the upper limit switch stops travel. To return the platform to the normal position, press "DOWN" button and hold in until the platform has completed the downward travel. In manual position, the tester will operate only as long as the "UP" or "DOWN" buttons are held in. Upon completion of the test, remove the breaking head from the tester and remove the tested specimen from the breaking head. Place master switch in the "OFF" position upon completion of all tests.

4. Maintenance

4.1 Breaking Head. The inside surfaces of the breaking head must be kept clean by wiping with a rag containing a suitable solvent. The guide rods and bushings must be kept clean and shall be lubricated by wiping with an oiled rag.

4.2 Testing Machine. The cams, pivots and rollers of the tester shall be lightly oiled approximately every three months. These points can be reached by removing the covers and the chart platen from the tester. The drive chain is accessible when the front control panel is removed from the tester. This chain shall be lubricated every six months with a light machine oil. In order to oil the entire chain, it is necessary to operate the tester manually to move the chain through short distances. WARNING: Since the front control panel must be removed to reach the drive chain, the contacts at the rear of this panel are exposed to the operator. These contacts are energized when the power plug is connected to the source of electricity. To avoid an electrical shock, it is essential that the power plug be disconnected immediately after advancing the chain and before attempting to oil the chain.

The weight pendulum must be firmly secured before the machine is moved. If the pendulum is not secured, the tester can be damaged. Unlock the pendulum before making any tests.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 724
October 1971
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

OPERATION OF AN AUTOMATIC MECHANICAL RECORDING TESTER (TYPE 2) FOR USE IN THE PDH DESIGN & CONTROL METHODS

1. Scope

1.1 This method covers the measurement of resistance to plastic flow of cylindrical specimens of Bituminous Paving Mixtures loaded on the lateral surface by means of the Pine Instrument Automatic Recording Tester.

2. Apparatus

2.1 Bituminous Tester. The bituminous tester shall be an Electric Automatic Recording Test Apparatus. The tester shall provide a uniform upward movement at the rate of 2 in. per minute and shall be capable of loading the specimen over three ranges of 0 to 2500, 5000, and 10,000 pounds.

2.2 Breaking Head. The breaking head shall consist of upper and lower cylindrical segments or test heads having an inside radius of curvature of 2 or 3 inches accurately machined and conforming to the dimensions of Figs. 3 and 6, respectively of PTM 705- . The lower segment shall be mounted on a base having two perpendicular guide rods or posts extending upward. Guide sleeves in the mount for the upper segment shall be in such a position as to direct the two segments together without appreciable binding or loose motion on the guide rods.

2.3 Water Bath. The water bath shall be at least six inches deep and shall be thermostatically controlled so as to maintain the bath at 140 F ± 1.8 F (60 F ± 1.0 C). A motor driven, propeller type agitator shall be provided to insure adequate mixing and circulation of the water. The tank shall have a perforated bottom or be equipped with a shelf for supporting specimens 2 inches above the bottom of the bath.

2.4 Recorder Charts. Recorder charts having an ordinate scale of 0 to 2500 pounds, 0 to 5000 pounds and 0 to 10,000 pounds and an abscissa scale of 0 to 35 flow units for each of the three charts shall be provided for recording of the stability and flow characteristics of the specimens.

2.5 Gloves. Long rubber gloves shall be provided to protect the operator when inserting or removing specimens from the water bath.

3. Procedure

3.1 Heating of Specimen. The bituminous paving material specimens prepared according to PDT Design and Control Methods shall be placed in the water bath in such a position that they are completely submerged and that the specimens do not touch each other. The specimens shall be heated for not less than 45 minutes nor more than 60 minutes.

3.2 Recorder Chart. The recorder chart is installed by laying a sheet on the recording writing surface and sliding it under the two holding clips on the left. The paper must be tight against the side bar and the bottom bar of the recorder writing surface.

3.3 Recorder Pen. The recorder pen is a Paper Mate Piggy-Back refill, although other types of ball-point pen refills may be used. The pen is inserted into the holder as follows:

3.3.1 Turn the instrument off.

3.3.2 Move the pen carriage by hand to a convenient location.

3.3.3 Move the pen raising lever all the way towards the back of the instrument. The pen raising lever is 1/16 in. in diameter and is located on the right side of the pen holder.

3.3.4 Insert the pen into the holder so that it touches the chart paper and secure the pen by making the screw in the front of the pen holder finger tight.

3.4 Load Range. The No. 750 Test Press has three ranges: 0 to 2500 pounds, 0 to 5000 pounds and 0 to 10,000 pounds. The desired range is selected by the RANGE knob on the front of the recorder.

3.5 Zero Adjustment. After the tester has been turned on, the desired range selected, pen and recorder chart properly in place, the recorder is adjusted to read zero pounds by turning the zero knob until the pen indicates zero pounds on the paper. If the pen does not indicate zero flow units on the recorder chart, it will be necessary to relocate the chart paper to obtain this adjustment.

3.6 Pen Check. To check to see if the ball point pen is working properly, gently move the pen carriage by hand across the bottom of the paper and back to zero again.

3.7 Limit Switches. The platen of the test press is limited to about 3/8 in. travel by limit switches. These limit switches are located below the right-hand end of the platen and are actuated by the LIMIT SWITCH ROD on the end of the platen. The limit switch rod is factory set to make the tester work properly. If it is necessary to change the travel of the platen, loosen the set screws on the right-hand end of the platen, adjust the limit switch rod, and retighten the set screws.

3.8 Motor Control Relay. The press drive motor is controlled by a motor reversing relay. The relay, in turn, is controlled by the UP, DOWN and STOP buttons, the limit switches controlling the platen travel, and an overload limit switch in the recorder.

NOTE 1--CAUTION. If the STOP and DOWN buttons are pushed in rapid succession when the platen is traveling up, or if the STOP and UP buttons are pushed in rapid succession when the platen is traveling down, this will cause the relay to reverse without the motor changing direction. In such a case the limit switches controlling the platen will not work as desired. Instead, the limit switches will deactivate both the UP and DOWN buttons and the tester will not operate.

To get the tester back in operation:

3.8.1 Lift the limit switch rod clear of the limit switches.

3.8.2 Press the UP or DOWN button to bring the platen into the proper position (7 in. from platen to load cell) and stop it there.

3.8.3 Replace the limit switch rod to its former position and tighten the set screws on the rod.

3.9 Overload Limit Switch. This switch is located on the recorder and is actuated when the pen carriage travels to the top of the chart paper. When the overload limit switch is operated, it turns off the pilot light on the recorder and shuts off the motor reversing relay. If the tester is shut off by the overload limit switch, the pen carriage must be moved down by hand until the pilot light comes on and then the DOWN button will work to remove the overload from the load cell.

3.10 Testing. Heat the testing head between 100 to 110 F (37.8 to 43.3 C) prior to making the first test. Remove the heated breaking head from the water bath and place it in front of the tester after separating the two portions of the head. Remove a specimen from the water bath and place it centrally on the lower segment. Place the upper segment in position over the guide rods and the specimen. Place the assembly on the lower platen of the tester and against the location pins so that the breaking head is centered under the load cell. Press the UP button to initiate the test. Upward travel of the platen will be stopped by the limit switch after 35 units of flow. When the motor has stopped, press the DOWN button to return the platen to the initial position. Upon completion of the test, remove the breaking head from the tester and remove the tested specimen from the breaking head. Place the master switch in the OFF position upon completion of all tests.

4. Maintenance

4.1 Breaking Head. The inside surfaces of the breaking head must be kept clean by wiping with a rag containing a suitable solvent. The guide rods and bushings must be kept clean and shall be lubricated by wiping with an oiled rag.

4.2 Testing Machine. The platen guide rods must be kept clean and shall be lightly lubricated by wiping with an oily rag.

Commonwealth of Pennsylvania
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Pa. Test Method No. 725
October 1971
1 Page

Bureau of Materials, Testing & Research

Method of Sampling

ROADWAY BITUMINOUS CONCRETE USING CUP-METHOD

1. Scope

1.1 This method covers the procedure for sampling bituminous paving mixtures taken from the finished roadway by the cup method for determination of the density of the mixture. This is a "quickie" method to check the rolling efficiency, but is not an official test.

2. Apparatus

2.1 Sufficient number of 16 oz cheese cups.

2.2 Suitable non-adhesive paper such as aluminum foil, butcher paper, etc.

2.3 Marking pencil.

2.4 Plywood or suitable material.

3. Samples

3.1 Four cup samples from the roadway.

4. Procedure

4.1 Prepare a sufficient number of 16 oz cheese cups. Cut off the bottom of the cup and then cut out a section so that the height of the cup will be the same as the depth of the material being laid behind the paver. Behind the paver, prior to rolling, remove material from an area approximately 6 in. by 6 in. for the full depth of the course being laid and place a piece of non-adhesive paper over the exposed area. Insert the cup on the paper and fill it with the unsegregated mix so that it is level with the material. Do not tamp the material, use only hand pressure in filling the cup.

4.2 After the material has been rolled and the pavement has been cooled, remove the cups with the material, and determine percent compaction based on the specific gravity of the daily compacted specimen. Remove the cups with material by prying with suitable tool (such as screw driver or putty knife, etc.).

4.3 Place on plywood or suitable material and secure with masking tape.

4.4 Identify samples according to PDT instructions.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 727
October 1971
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

WATER IN PETROLEUM PRODUCTS AND BITUMINOUS MATERIALS BY DISTILLATION

1. Scope

1.1 This method of test is used to determine the water content of bituminous materials by distillation with a water-immiscible, volatile solvent. The method is suitable for a variety of bituminous materials, but it is especially applicable to crude petroleums and tars and products derived from them, such as fuel oils, road oils, creosotes, road tars, asphalts, and crude or refined tar acids. This method of test is a modification of AASHO T 55- .

2. Summary of Method

2.1 The material is heated under reflux with a water-immiscible solvent which co-distills with the water in the sample. Condensed solvent and water are continuously separated in a trap, the water settling in the graduated section of the trap and the solvent returning to the still.

3. Apparatus

3.1 The apparatus comprises a glass or metal still, a heater, a reflux condenser, and a graduated glass trap. The still, trap, and condenser may be connected by any suitable method for producing a leakproof joint. Preferred connections are ground joints for glass to glass and O-rings for metal to glass. Typical assemblies are illustrated in Figs. 1 and 2.

3.2 Still. A glass or metal vessel having a nominal capacity of 500, 1000 or 2000 ml and a short neck accommodating the reflux tube of the trap.

3.3 Heater. Any suitable gas burner or electric heater may be used with the glass flask. A gas ring burner with ports on the inside circumference shall be used with the metal still.

3.4 Condenser. A straight tube condenser, having a jacket at least 400 mm long and an inner tube whose outside diameter is 9.5 to 12.7 mm.

3.5 Trap. A glass trap of 10 or 25 ml capacity. The traps shall be graduated in 0.1 ml divisions with a ± 0.05 ml maximum error below 1 ml, and in 0.2 ml divisions with a ± 0.1 ml maximum error above 1 ml.

4. Solvent

4.1 For general use an aromatic solvent is preferred since it has high solvency and dispersing power for most bituminous materials. Xylene, or a blend of 20 percent benzene and 80 percent xylene, is recommended.

4.2 For asphalts and similar petroleum products, a petroleum distillate, 5 percent boiling between 194 and 212 F, and 90 percent distilling below 410 F may be used.

4.3 For coal-tar, water-gas tar, and similar materials, the aromatic solvent must be used.

5. Sample

5.1 The portion of the sample used for the test must be thoroughly representative of the total sample. If the material is liquid, thoroughly stir the sample as received, warming if necessary, to insure uniformity. Crush the solid materials that are sufficiently brittle, mix thoroughly, and take a representative sample for analysis. When there is doubt as to the uniformity of the material, run a number of samples and average the data.

5.2 Base the size of the test portion on the estimated water content of the sample, such that the water yield does not exceed the capacity of the trap.

6. Procedure

6.1 Transfer a suitable amount of sample, measured with an accuracy of ± 1 percent, to the still. Measure ordinary liquid samples in a graduated cylinder of appropriate size. Rinse the material adhering to the cylinder into the still with one 50 ml and two 25 ml portions of the solvent. Drain the cylinder thoroughly after the sample transfer and each rinsing. Weigh solid or semisolid materials or bituminous emulsions directly into the still and add 100 ml of solvent. When large samples are being analyzed, a solvent volume in excess of 100 ml may be necessary.

6.2 Assemble the components of the apparatus as illustrated in Figs. 1 and 2, making all connections vapor and liquid tight. If a metal still with removable cover is used, insert a gasket of heavy paper, moistened with solvent, between the still body and cover. The condenser tube and trap must be chemically clean to assure free drainage of water into the bottom of the trap. Insert a loose cotton plug in the top of the condenser to prevent condensation of atmospheric moisture inside it. Circulate cold water through the jacket of the condenser.

6.3 Apply heat to the still, adjusting the rate of boiling so that condensed distillate discharges from the condenser at the rate of 2 to 5 drops per second. If the metal still is used, start heating with the ring burner about 3 in. above the bottom of the still and gradually lower the burner as the distillation proceeds. Continue distillation until no water is visible in any part of the apparatus except in the trap. If there is a persistent ring of water in the condenser tube, increase the rate of distillation or cut off the condenser water for a few minutes.

6.4 When the evolution of water is completed, allow the trap and contents to cool to room temperature. Dislodge any drops of water adhering to the sides of the trap with a glass or polytetrafluorethylene rod or other suitable means and transfer them to the water layer. Read the volume of the water in the trap to the nearest scale division.

7. Report

7.1 Report the water in the sample as percent by weight or volume, according to the basis on which the sample was taken, calculated as follows:

$$\text{Water, percent} = \frac{\text{Vol. of water in trap}}{\text{wt. (or vol.) of sample}} \times 100$$

Volatile water-soluble material present may also be measured as water.

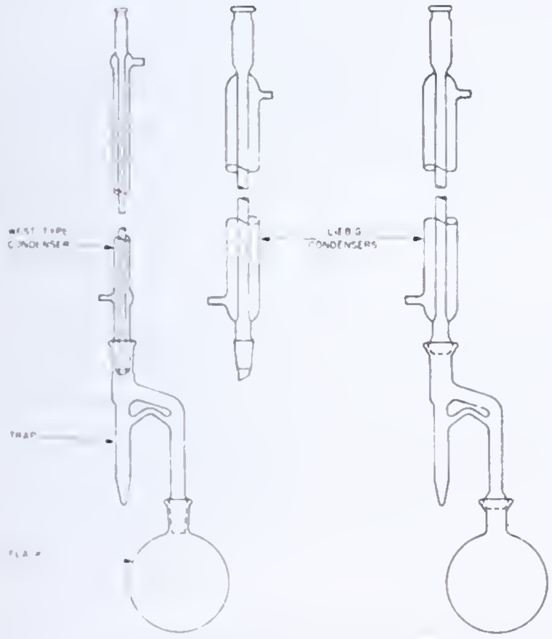
8. Precision

8.1 Two tests of the same material should agree within the greater of the following limits:

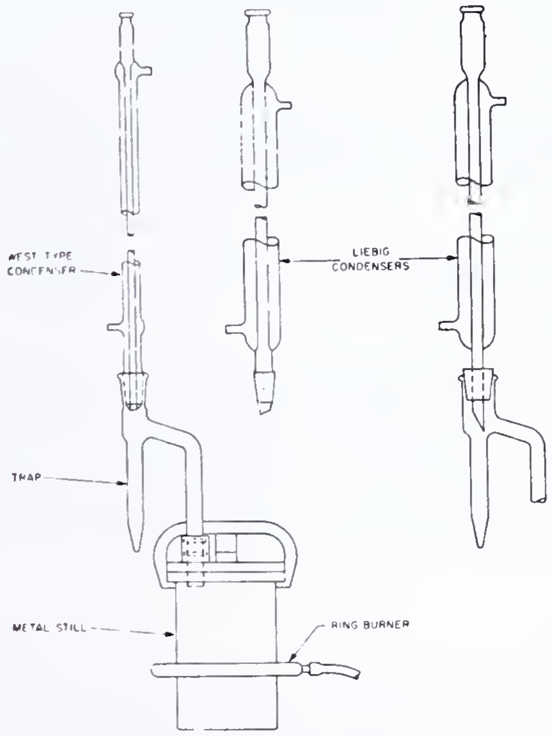
Volume of Water Collected, ml	Repeatability (Same Apparatus and Operator)	Reproducibility (Different Apparatus and Operator)
0 to 1---------------	0.1 ml	0.2 ml
Over 1 to 25-----	0.1 ml or ± 1 percent of the mean	0.2 ml or ± 5 percent of the mean

9. Reference

AASHO T 55-



NOTE.—Trap shall be 15 to 16 mm inside diameter.
FIG. 1.—*Typical Assemblies with Glass Flask.*



NOTE.—Trap shall be 15 to 16 MM inside diameter.
FIG. 2.—*Typical Apparatus Assemblies with Metal Still.*

Commonwealth of Pennsylvania
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Pa. Test Method No. 728
October 1971
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

OPERATION OF AN AUTOMATIC MECHANICAL RECORDING TESTER (TYPE 3) FOR USE IN PDH DESIGN AND CONTROL METHODS

1. Scope

1.1 This method covers the measurement of the resistance to plastic flow of cylindrical specimens of bituminous paving mixtures loaded on the lateral surface by means of the Rainhart Series 760 Automatic Tester and Recorder.

2. Apparatus

2.1 Bituminous Tester. The bituminous tester shall be an automatic mechanical tester providing a uniform downward movement at the rate of 2 in. per minute and shall be capable of loading the specimen over the ranges of 0 to 2500, 0 to 5000, and 0 to 10,000 pounds.

2.2 Recorder. The recorder shall be an electronic strip chart servo-recorder. The width of the strip chart shall be graduated into 100 uniform divisions and be printed with three load scales corresponding to the range of the automatic tester. The length of the chart shall be divided into uniform divisions which represent 0.01 in. of breaking head travel. The chart speed shall be 40 in. per minute to correspond to the closing speed of the automatic tester.

2.3 Water Bath. The water bath shall be at least 6 in. deep and shall be thermostatically controlled so as to maintain the bath at 140 F ± 1.8 F (60 C ± 1.0 C). A motor driven propeller type agitator shall be provided to insure adequate mixing and circulation of the water. The tank shall have a perforated bottom or be equipped with a shelf for supporting specimens 2 in. above the bottom of the bath.

2.4 Gloves. Long rubber gloves are required to protect the operator when inserting or removing specimens from the water bath.

2.5 Breaking Head. The breaking head shall consist of upper and lower cylindrical segments or test heads having an inside radius of curvature of 2 in. or 3 in. accurately machined and conforming to the dimensions of Figs. 3 and 6, respectively of PTM 705- . The lower segment shall be mounted on a base having two perpendicular rods or posts extending upwards. Guide sleeves in the mount for the upper segment shall be in such a position as to direct the two segments together without appreciable binding or loose motion on the guide rods.

3. Procedure

3.1 Heating of Specimens. The bituminous paving material specimens prepared according to PDH Design and Control Method shall be placed in the water bath in such a position that they are submerged completely and that the specimens do not touch each other. The specimens shall be heated for not less than 45 minutes nor more than 60 minutes.

3.2 Recorder Chart. Remove the cover plate on the recorder, remove the chart spindle and place it through the core of the recorder chart roll. Place the roll and spindle in the recorder so that the chart feeds from the bottom of the roll. Pull the end of the chart forward and insert it under the guide plate so that the perforations engage the drive sprockets.

3.3 Recorder. Insert the five-pronged connecter which is attached to the recorder into the receptacle on top of the switch box at the front of the tester. Insert the color coded plugs which lead from the load cell into the same colored connectors on top of the recorder. Turn the main switch ON and turn the Chart Drive switch on the recorder to STANDBY. Allow the recorder to warm-up for 30 minutes. Insert the fountain pen or felt tip pen into the spring holder at the front of the recorder in such a position that the point just touches the paper. The pen may be raised from contact with the chart by means of the Pen Lift Knob on the left side of the recorder. Advance the chart manually with the knob on the left side of the recorder until the pen is zeroed at the start of the chart. After the unit has warmed up, the pen may be set for zero pounds by turning the Chart Drive knob to SERVO and then turning the Zero knob to obtain the adjustment. If chatter or fluctuations appear in the pen, this will be eliminated by adjustment of the damping control. The chart drive position of the controls is used only for rapid advancement of the chart. The wiring of the recorder has been changed so that the chart will be advanced automatically when the tester is started and the Chart Drive control is in the SERVO position. Return the control to STANDBY when the tester is not being used. The recorder can be set for maximum ranges of 2500, 5000, and 10,000 pounds by operation of the Range Control.

3.4 Automatic Tester. Heat the breaking head assembly to 100 to 110 F (37.8 to 43.3 C) prior to making the first test. Remove the heated breaking head from the water bath and place it in front of the tester. Separate the heads. Remove a specimen from the water bath and place it centrally on the lower segment. Place the upper segment in position over the guide rods and the specimen. Place the assembly on the lower platen of the tester against the location pins so that the breaking head is centered under the load cell in the upper part of the tester. Move the motor control lever downward until the handle is held by the detent. Release pressure on the handle. The tester will apply pressure to the specimen until the maximum amount of movement has been obtained, and at this point the limit switch will stop the motor. When the motor has stopped, raise the motor control lever to the upper position until it has been held by the detent. Release pressure on the handle. The tester will stop automatically when in fully opened position. Remove the breaking head from the tester and remove the tested specimen from the breaking head. Advance of the chart paper will be stopped as soon as the tester completes the closing operation and it will not advance during the tester opening operation. Advance the chart manually to the TEAR position and remove the chart from the recorder.

NOTE 1--The tester will not operate unless the 5-prong plug from the recorder is plugged into the main switch box and the two plugs from the load cell are connected to the recorder.

NOTE 2--Travel of the loading head of the tester is controlled by the small collars positioned on the limit switch rod. These collars will have to be positioned by trial and error.

NOTE 3--The ring dynamometer furnished with the tester is used to check the load calibration of the tester. When the dynamometer is positioned in the tester, various loads can be applied to the load cell by manually turning the drive pulley counter clockwise. The drive belt can be removed from the motor pulley as a safety measure.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 729
February 1976
4 Pages

Bureau of Materials, Testing & Research

Method of Sampling

SAMPLING ROADWAY BITUMINOUS CONCRETE

1. Scope

1.1 This method covers the procedure for sampling of bituminous paving mixtures taken from the finished pavement for determination of the characteristics of the compacted mixture. Method C is suitable for rapid determination of pavement density while the work is in progress.

METHOD A (SAWING)

2. Equipment

2.1 Power-driven, water cooled, abrasive, circular saw.
2.2 Suitable non-adhesive material, such as aluminum or metal foil, butcher paper etc.
2.3 A rigid plate or a suitable container large enough to hold the sample without distortion after it is removed from the pavement.
2.4 Masking tape and roofing nails.
2.5 Marking pencil.

3. Samples

3.1 A 12 in. by 12 in. roadway section for the full depth of the course or courses.

4. Procedure

4.1 Place a 12 in. square of the non-adhesive material in the area selected by the engineer. Unless otherwise directed, it should not be placed any closer than 2 ft. from the edge of the lane or from a longitudinal joint.
4.2 Tie in the four corners of the square by measuring from known points, and recording the distances.
4.3 After the pavement is laid and compacted, nail redheads (nails with a square red cloth attached to their heads) in the four corners of the square beneath the pavement. This will identify the location of the sample when it is to be cut out and removed.
4.4 Saw the samples for the full depth of the wearing and binder courses, remove the sawed specimens and place in the suitable container. Care should be exercised that the sample is not distorted, bent, cracked or in any way changed from its physical condition as it was before removal from the pavement. The non-adhesive material should be removed carefully from the sawed specimen.
4.5 Secure the specimens with masking tape. Specimens shall be stored in a safe, cool place.
4.6 Identify sample according to PDT instructions.

METHOD B (CORING)

5. Equipment

5.1 Core drill, water cooled, equipped to core and retrive specimens.
5.2 Drill bits of 4 in., 6 in. and 8 in. sizes, diamond.
5.3 Incidental materials and equipment.
5.4 A rigid plate or a suitable container large enough to hold the sample without distortion, after it is removed from the pavement.

5.5 Masking tape.
5.6 Marking pencil.

6. Samples

6.1 The size and number of samples shall be designated by the engineer.

7. Procedure

7.1 The areas to be cored shall be selected by the engineer. Refer the Illustrative Example No. 3 given in the Appendix of PTM No. 746 for random sampling.

7.2 Core the samples, remove and place in the suitable container. Care should be exercised while retrieving that the cored sample is not distorted, bent, cracked or in any way changed from its physical condition as it was before removal from the pavement.

7.3 Secure the cored specimens with masking tape. Specimens shall be stored in a safe, cool place.

7.4 Identify the samples according to PDT instructions.

METHOD C (DENSITY RING METHOD)

8. Equipment and Materials

8.1 Density ring. The density ring shall be of steel, approximately 6 in. inside diameter and approximately ¼ in. less in height than the thickness of the compacted layer of asphalt mix from which the specimen is to be removed.

8.1.1 Rings of the required height may be cut from low carbon, cold drawn, seamless, mechanical tubing, 6 in. inside diameter and ¼ in. wall thickness.

8.1.2 The lower part of the outside wall of the ring shall be cut on a bevel (approx. 20°) until the bottom edge is approx. 1/8 in. wide. The ring shall be trued, so that the top and bottom edges are parallel to each other and perpendicular to the inside wall.

8.1.3 The wall shall be cut through at one location as shown in Figure 1. The cut section shall be approx. 1/16 in. wide, or as cut by the saw blade. If the cut should open more than is desirable, it may be brought back to the desired dimension by compressing the open ring in a vise.

8.1.4 A hole approx. 1/8 in. diameter shall be drilled in the ring wall opposite the cut section. The center of the hole shall be approx. 3/16 in. from the upper edge of the ring. By means of the hole, a suitable wire may be attached to the ring to aid in removal of the ring and specimen from the compacted pavement. All edges of the split ring, including the cut section, shall be deburred and made smooth by filing.

8.2 Suitable non-adhesive material, such as aluminum or metal foil, butcher paper, etc.

8.3 A rigid plate or a suitable container large enough to hold the sample without distortion after it is removed from the pavement.

8.4 Masking tape.
8.5 Marking percil.
8.6 Large screwdriver.
8.7 Dry ice in plastic bags.

9. Procedure

9.1 On the base or leveling course on which the asphalt mix is being placed, and at the selected location, place the density ring with beveled edge down ahead of the spreading operation. If desired, a piece of aluminun foil slightly larger than the density ring may be placed between the ring and the base or leveling course.

9.2 A string may be attached to the short wire affixed to the density ring and led to an area outside the spreading operation. After the spreading machine has passed over the density ring, but before rolling operations are begun, the string and wire are lifted thru the uncompacted mix and left on the surface. After rolling operations are complete, the string and wire are lifted from the surface to the location of the density ring and enclosed specimen. By means of the attached wire, and with the aid of a pry (large screwdriver will do), the density ring and the enclosed specimen shall be removed from the pavement. Dry ice in a plastic bag may be used to cool the compacted mix before the ring and specimen are removed. After the ring and specimen are removed, material near the upper edge (above the density ring) which may have been loosened or distrubed during the removal operation, shall be trimmed from the undisturbed portion of the specimen.

9.3 To remove the specimen from the ring, a strong screwdriver is inserted into the cut-section and turned to expand the ring and allow the specimen to drop out, or to be pushed out. Care must be exercised so the compacted specimen will not be deformed during the removal operation.

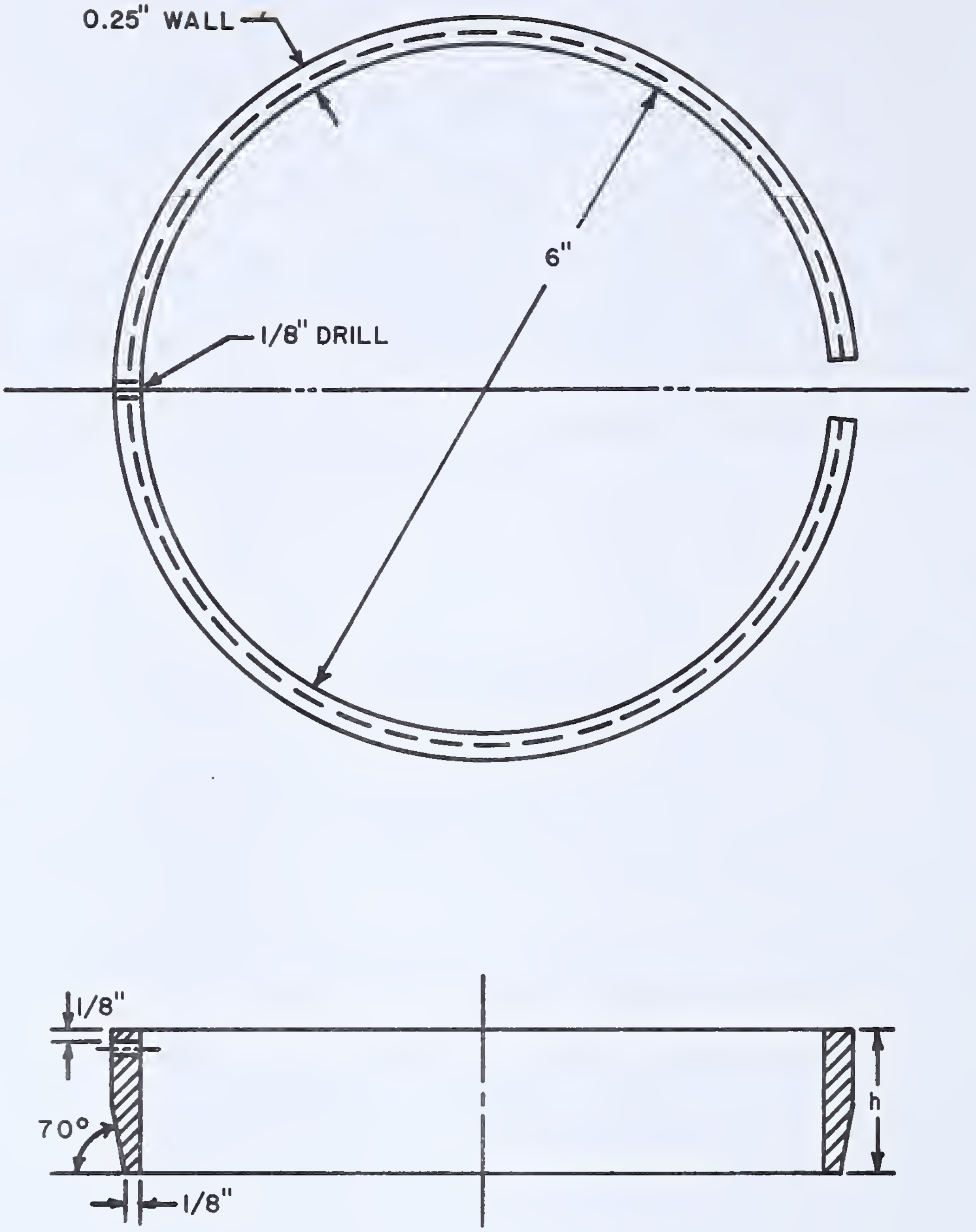
9.4 Specimen retrieved by this method are practically free of moisture and, therefore, are suitable for density determination at the job-site.

9.5 If the specimens are to be sent to the laboratory, place in a suitable container. Secure the specimens with masking tape and store in a safe, cool place.

9.6 Identify the samples according to PDT instructions.

10. References

AASHTO T 230
PTM No. 746



NOTE: h = 1/4" LESS THAN THICKNESS
OF COMPACTED LAYER FROM WHICH
THE SPECIMEN IS TO BE REMOVED
ALL DIMENSIONS ARE APPROXIMATE

FIG. 1 - TYPICAL PAVEMENT DENSITY RING

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 731
October 1971
9 Pages

Bureau of Materials, Testing & Research

Method of Sampling

SAMPLING BITUMINOUS MATERIALS

1. Scope

1.1 This method applies to the sampling of liquid, semi-solid, or solid bituminous materials at the point of manufacture, supply terminal, or at the point of shipment delivery.

1.2 Samples may be taken from tanks, stockpiles, vehicles, or containers used for the storage or shipping of bituminous materials.

2. Purpose

2.1 Sampling is as important as testing, and every precaution shall be taken to obtain samples that will show the true nature and condition of the materials.

2.2 Samples may be taken by methods to be described hereinafter for either of the following two purposes.

2.2.1 To represent as nearly as possible an average of the bulk of the material sampled or

2.2.2 To ascertain the maximum variation in characteristics which the material possesses.

3. Size of Samples

3.1 The sample size of liquid materials shall be as follows:

3.1.1 For routine laboratory examination not less than 1 qt. (1 liter) (emulsions, 2 qt). (2 liters).

3.1.2 From bulk storage, 1 qt. (1 liter) for each sampling valve,

3.1.3 From barrels or drums, 1 qt. (1 liter),

3.2 The sample size of semisolid or solid materials shall be as follows:

3.2.1 From barrels, drums, or cakes, 2 to 3 lb (1 kg),

3.2.2 From crushed or powdered material in bulk or bags, 2 to 3 lbs. (1 kg).

4. Containers

4.1 Types of Containers.

4.1.1 Containers for liquid bituminous material samples, except emulsion, shall be double friction-top cans, or square cans with screw tops.

4.1.2 Containers for anionic emulsified asphalt samples shall be widemouth jars or bottles made of glass or plastic.

4.1.3 Containers for cationic emulsified asphalt samples shall be widemouth jars or bottles made of plastic or widemouth cans with screw caps.

4.2 Size of Containers

4.2.1 The size of the container shall correspond to the required amount of sample.

5. Protection and Preservation of Samples

5.1 Sample containers shall be new. They shall not be washed or rinsed, or wiped with oily cloth. If they contain evidence of solder flux, or if they are not clean and dry, they shall not be used. Top and container shall fit together tightly.

5.2 Care shall be taken to prevent the sample from becoming contaminated. Immediately after filling, the containers shall be tightly and positively sealed.

5.3 The filled sample container shall not be submerged in solvent, or shall it be wiped with a solvent saturated cloth. If cleaning is necessary use a clean dry cloth.

5.4 Samples of emulsion shall be protected from freezing by correct packaging.

5.5 Transferring samples from one container to another shall be avoided if possible, as characteristics of materials could be altered during transfer, and there is a possibility of contamination.

6. Sampling at Place of Manufacture

6.1 Sampling Liquid Materials or Materials Made Liquid by Heating.

6.1.1 From bulk Storage Tanks Not Equipped with Mechanical Agitators

NOTE 1 — During sampling by any of the methods described all filling inlets and discharge outlets of the tank shall be closed.

Samples shall be obtained by one of the three following methods:

6.1.1.1 Tank Tap Method — Using valves or taps at top, middle, and lower locations of the tank draw a 1 qt. to 1 gal. (1 to 4 liters) sample from each after clearing by drawing and discarding a minimum of 3 gal. (12 liters) of the material.

6.1.1.2 Thief Sampler Method (not suitable for asphalt cements), — Samples shall be taken at top, and lower levels of the tank by lowering a Thief Sampler into the material. A satisfactory type with instructions for use is shown in Fig. 1.

NOTE 2 — The Thief Sampler described in Fig. 1 may be used for repetitive sampling because significant sample contamination by previous contents is avoided by the self-cleaning action provided by the passage of material through the tube which is open at both ends. The practice of raising and lowering the sampler 3 or 4 times through a distance of several feet of the sampling depth is recommended.

6.1.1.3 Throw-away Container Method. — Samples shall be taken at top, middle, and lower levels of the tank by lowering a suitable weighted holding device into the material. A satisfactory type with instructions for use is shown in Fig. 2. The essential feature of the method is to use a clean container each time a sample is taken from the tank, pouring the sample into another clean container and throwing away the container used in sampling.

6.1.1.4 The three samples from bulk storage tanks may be tested separately for consistency to detect stratification; or they may be combined, throughly mixed, and a 1 qt. to 1 gal (1 to 4 liters) sample taken for other tests as may be required for determining average characteristics of the material.

6.1.2 From Bulk Storage Tanks Equipped with Mechanical Agitators. — When the tank is equipped with operating mechanical agitators which, by observation through the sampling or observation hatch, are performing adequate mixing of the tank contents, a single sample taken by methods described in 6.1.1.1, 6.1.1.2, 6.1.1.3 will be satisfactory to use for test purposes.

7. Sampling from Tank Cars, Tank Trucks, Distributor Trucks or Recirculating Storage Tanks

7.1 Each delivery vehicle or distributor shall be equipped with a sampling valve similar in design to those shown in Fig. 3. It shall be installed at least one foot (0.3 m) from the shell and shall be clearly labeled as a "Sampling Valve". Before the sample is taken from the sample valve a minimum of 3 gal (12 liters) shall be drawn from the sample valve and discarded.

7.2 When permitted by the purchaser, the following methods may be used to obtain representative samples.

7.2.1 Samples of liquid materials and materials made liquid by heating may be taken by the dip method using a clesn small-mouth or friction-top can in a suitable holder as shown in Fig. 4. A clean container must be used to take each sample, and the material sampled shall then be transferred to another new and clean container for retention or sample testing.

7.2.2 A detachable fitting, similar in design to the one shown in Fig. 5 shall be inserted in the discharge line. Before the sample is taken 3 gal. (12 liters) shall be drawn from this sampling valve and discarded.

8. Sampling from Tankers and Barges

8.1 For liquid materials including all cutbacks made liquid by heating, top middle and lower samples shall be taken using the methods as described in 6.1.2.

8.2 For all other materials made liquid by heating, a top sample only shall be taken by the dip, thief, or throw-away container method.

9. Sampling from Pipe Lines during Loading or Unloading

9.1 When tankers and barges are being loaded or unloaded samples may conveniently be taken from the pipe line through which the material is flowing by insertion of a sampling device (Fig. 5) into a [illegible] section of the pipe line on the discharge side of the pump or in a completely filled line in which gravity creates the materials flow. The sampling device should be turned to face the flow of the liquid. This device shall be provided with a valve or plug cock and shall discharge into a sample receiver. At least three 1 gal samples shall be taken at uniform intervals throughout the entire loading or unloading. At the completion of the loading or unloading, the individual 1 gal (4 liter) samples shall be combined, thoroughly mixed without altering its characteristics, and a 1 gal (4 liter) sample taken therefrom.

9.2 When sampling tankers and barger 25,000 bbl., or less, capacity, at least five 1 gal (4 liter) samples shall be taken at uniform intervals throughout the entire loading or unloading (25,000 bbl. or larger, capacity requires at least ten 1 gal (4 liter) samples). At completion of the loading or unloading the individual 1 gal (4 liter) samples shall be combined, thoroughly mixed in a manner designed to not alter its characteristics, and a 1 gal (4 liter) sample taken therefrom.

10. Sampling from Drums or Barrels

10.1 After thorough mixing, samples of liquid bituminous material from barrels or drums shall be secured by Tube or Thief Sampling by taking 1 qt (1 liter) of material from packages selected at random according to Sampling Semisolid or Uncrushed Solid Materials.

11. Sampling Semisolid or Uncrushed Solid Materials

11.1 Drums, Barrels, Cartons, and Bags. — Where the lot of material to be sampled is obviously from a single run or batch of the producer, one package shall be selected at random and sampled as described below. Where the lot of material to be sampled is not obviously from a single run or batch of the producer, or where the single sample selected as described above fails on test to conform to the requirements of the specifications, a number of packages shall be selected at random equivalent to the cube root of the total number of packages in the lot. The following table is given showing the number of samples to be selected for shipments of various sizes.

Packages in Shipment	Packages Selected
2 to 8	2
9 to 27	3
28 to 64	4
65 to 125	5
126 to 216	6
217 to 343	7
344 to 512	8
513 to 729	9
730 to 1000	10
1001 to 1331	11

Samples shall be taken from at least 3 in. (76 mm) below the surface and at least 3 in. (76 mm) from the side of the container. A clean hatchet may be used if the material is hard enough to shatter and a broad, stiff putty knife if the material is soft. When more than one package in a lot is sampled each individual sample shall be not less than ¼ lb (115 g) in weight. When the lot of material is obviously from a single run or batch of the producer, all samples from the lot shall be melted and thoroughly mixed, and an average 1 gal (4 liter) sample taken from the combined material for examination. In case more than a single run or batch of the producer is present and the batches can be clearly differentiated, a composite 1 gal (4 liter) sample shall be prepared for examination from each batch. Where it is not possible to differentiate between the various batches, each sample shall be examined separately.

12. Sampling Crushed or Powdered Materials

12.1 Bulk Storage — Solid bituminous materials in crushed fragments or poweder shall be sampled in accordance with the ASTM D 346, Sampling Coke for Analysis. The gross sample shall be not less than 50 lb (25 kg), from which shall be selected the 2 to 3 lb (1 kg) sample for test.

12.2 Drums, Barrels, Bags, Cartons — Where the crushed or powedered material is in barrels, drums, or bags, a number of packages shall be selected at random as described in 11.1 Sampling Semisolid or Uncrushed Solid Materials. A sample at least 1½ lb (0.7 kg) in weight shall be selected from near the center of each container to yield a gross sample weighing not less than 50 lb (25 kg) from which the 2 to 3 lb (approx 1 kg) sample for test shall be selected as prescribed in the ASTM D346.

13. Sampling at Point of Shipment Delivery

13.1 Sampling of bituminous materials shall be done as soon as practicable after the bituminous material has arrived at plant site, storage site, or job destination or at the time of unloading.

13.2 Sampling shall be done by one of the three following methods:

13.2.1 In accordance with Section 6, Sampling at Place of Manufacture.

13.2.2 By bleeding through a sample valve or tap in the transfer line during the uloading of the approximate middle-third of the load, or

13.2.3 By means of a sampling device inserted to a level of approximately the middle-third of the load or tank. (Fig. 3)

14. Precautions

14.1 Because of the numerous types and grades of bituminous materials that are alternately shipped and stored in the same or similar containers, the opportunity for contaminating these containers with residues, precipitates, cleaning solvents, is ever present. Numerous opportunities also exist for obtaining sample which are not strictly representative of the material or are contaminated after removal. Therefore it is incumbent upon the producer, transporter, user, and sampler, to exercise continuous precaution in the sampling and handling of these materials.

This method of sampling combines PTM 731, 732, 733, 734, 735, Refer to AASHO T-40.

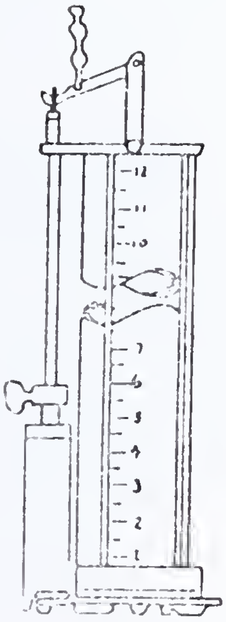


FIG. 1—Thief Sampler.

NOTE.—This type sampler is lowered into the tank with the bottom valve open (there is no top closure). When the desired depth is reached, the lowering chain is given a snap tug which closes the bottom valve. The sampler is then withdrawn from the tank and the contents transferred to the sample container. This sampler may be used for repetitive sampling in the same tank.

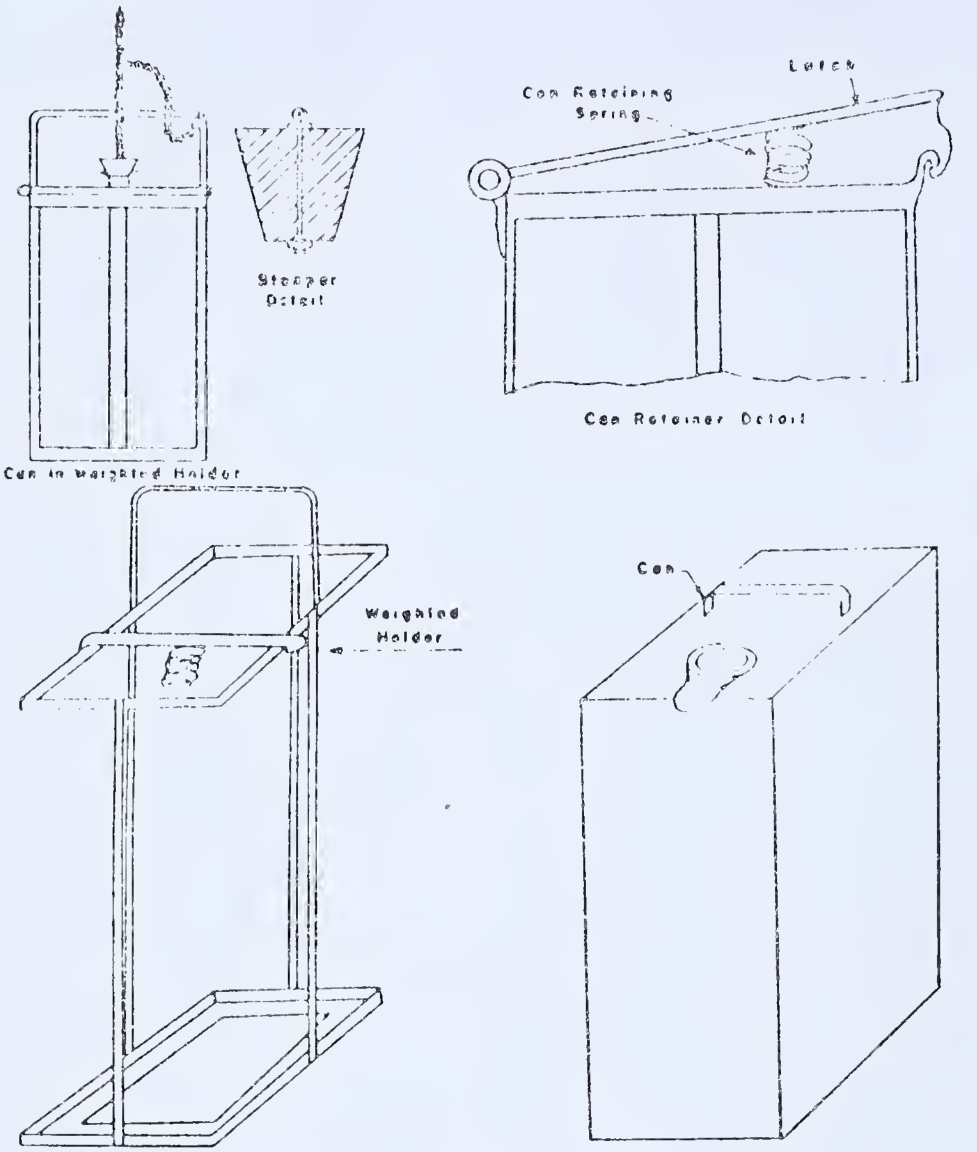


FIG. 2—Throw-away Container Sampler.

NOTE.—This type of sampler is lowered into the tank with the stopper in place. When the desired depth is reached, the stopper is removed by means of the attached wire, cord or chain and the container allowed to fill. Complete filling is indicated by the cessation of bubbles of air from the can at the surface of the liquid. The sample is then withdrawn from the tank and the contents poured into the clean sample container. A clean can (bottle) must be used for each sample taken.

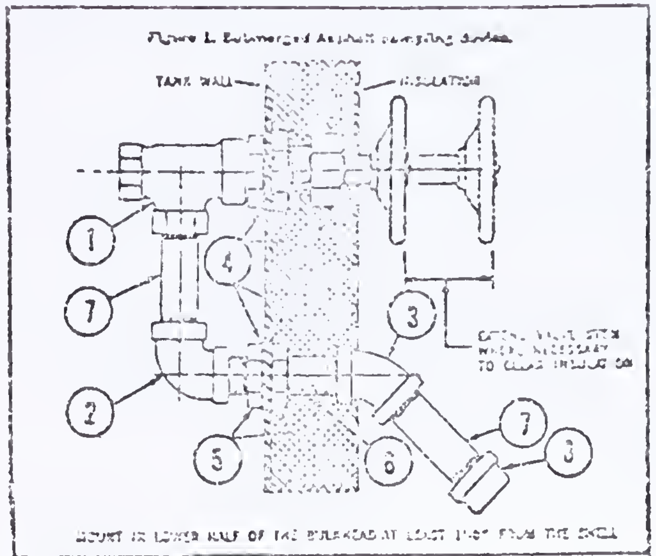
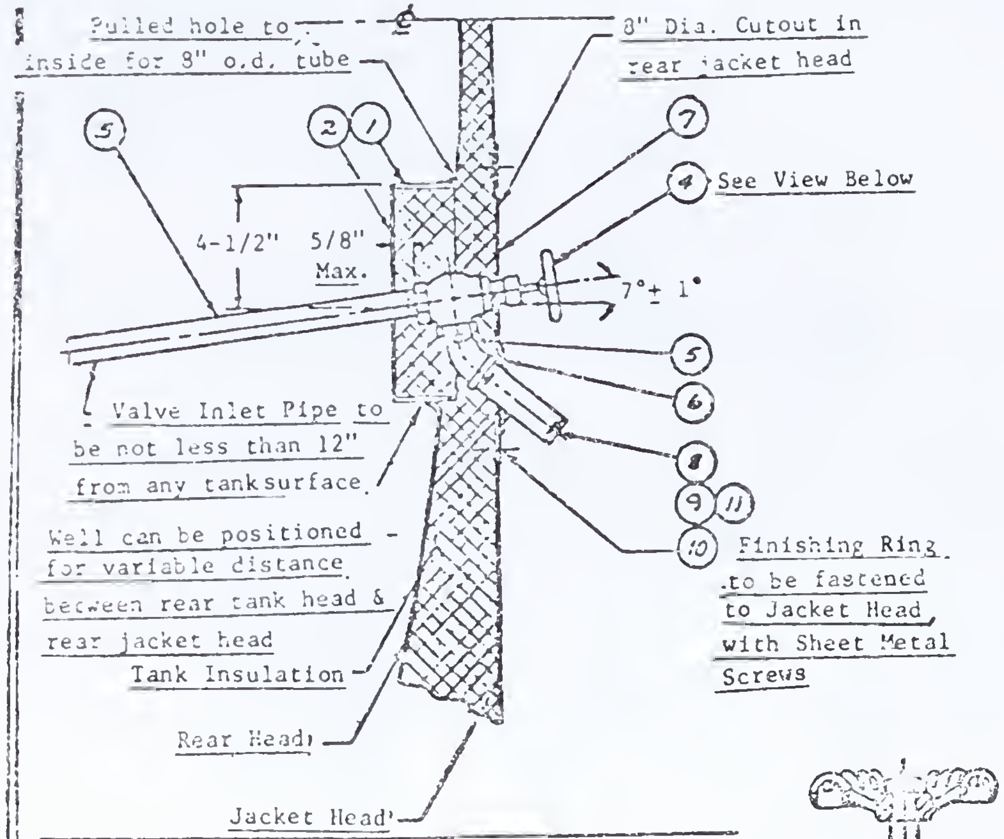
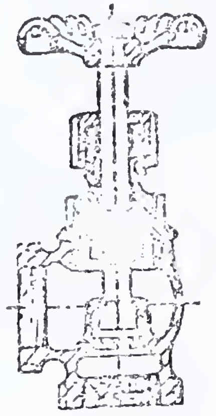


Figure 1. Submerged Asphalt Sampling Device.
TANK WALL
INSULATION
EXTEND VALVE STEM WHERE NECESSARY TO CLEAR INSULATION
MOUNT IN LOWER HALF OF THE BULKHEAD AT LEAST 1'-0" FROM THE SHELL
1
7
4
3
2
5
6
7
3

REF. No.	DESCRIPTION	No. REQ.
1	¾" VOGT P-8?4 STEEL ANGLE VALVE OR SIMILAR, PANEL MOUNTED	1
2	¾" STEEL OR MALL. IRON 90° ELBOW	1
3	¾" STEEL OR MALL. IRON 45° ELBOW	1
4	ASBESTOS GASKETS SNUG ON THREAD OR WOUND WITH YARN	4
5	¾" 150 # SCREWED M. I. LOCKNUT	2
6	¾" x 3½" ± PARALLEL THREADED STEEL PIPE NIPPLE (CUT FROM ¾" STD. TANK NIPPLE IF OTHERWISE UNOBTAINABLE)	1
7	¾" x 3" THREADED STEEL PIPE NIPPLE	2
8	¾" MALL. IRON PIPE CAP	1


Pulled hole to inside for 8" o.d. tube
8" Dia. Cutout in rear jacket head
See View Below
7° ± 1°
4-1/2"
5/8" Max.
Valve Inlet Pipe to be not less than 12" from any tank surface
Well can be positioned - for variable distance between rear tank head & rear jacket head
Tank Insulation
Rear Head
Jacket Head
Finishing Ring to be fastened to Jacket Head with Sheet Metal Screws
1
2
5
7
4
5
6
8
9
11
10

1	1	2780020	COLLAR-RECESS, SAMPLE VALVE
2	1	2780019	PLATE-END, RECESS, SAMPLE VALVE
3	1	6200284	PIPE-INLET, ¾" x 13 1/2, T.O.E.
4	1	6600349	VLV.-¾", ANGLE, CRANE, #2
5	1	0140798	ELBOW-45°, STREET, ¾"
6	1	2750166	RING-FIN, THERM. WELL
7	1	2780021	RING-FIN, RECESS, SAMPLE VALVE
8	1	0190724	NIPPLE-PIPE, ¾" x 4" LG.
9	1	2780033	CAP ASM.-SAMPLING VALVE
10	12	0144736	SCREW-PARKER KALON, #14
11	2	6000435	RIVET-SOUTHCO, #22-06-05, 3/16 x 3/32 LG.



Typical section view of valve (3/4 bronze angle)

FIG. 3.—Typical Submerged Asphalt Sampling Devices.

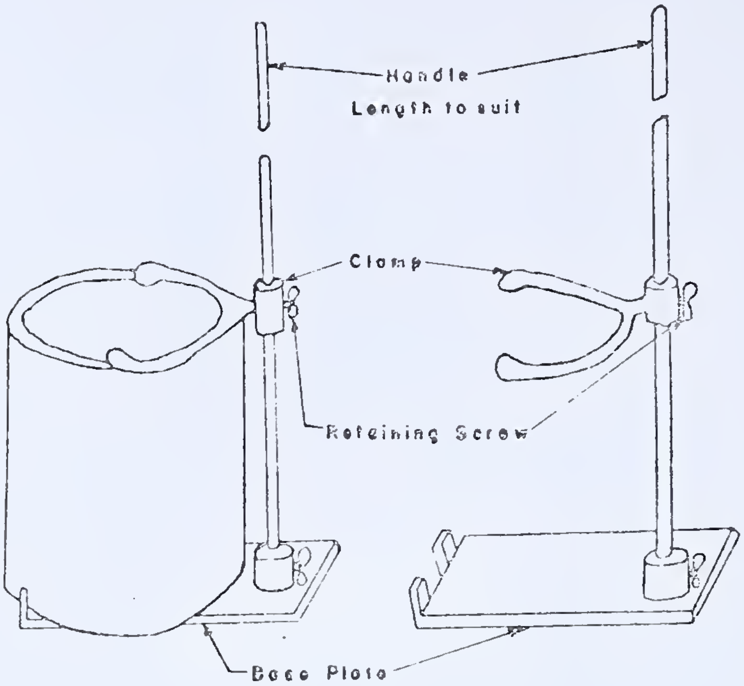
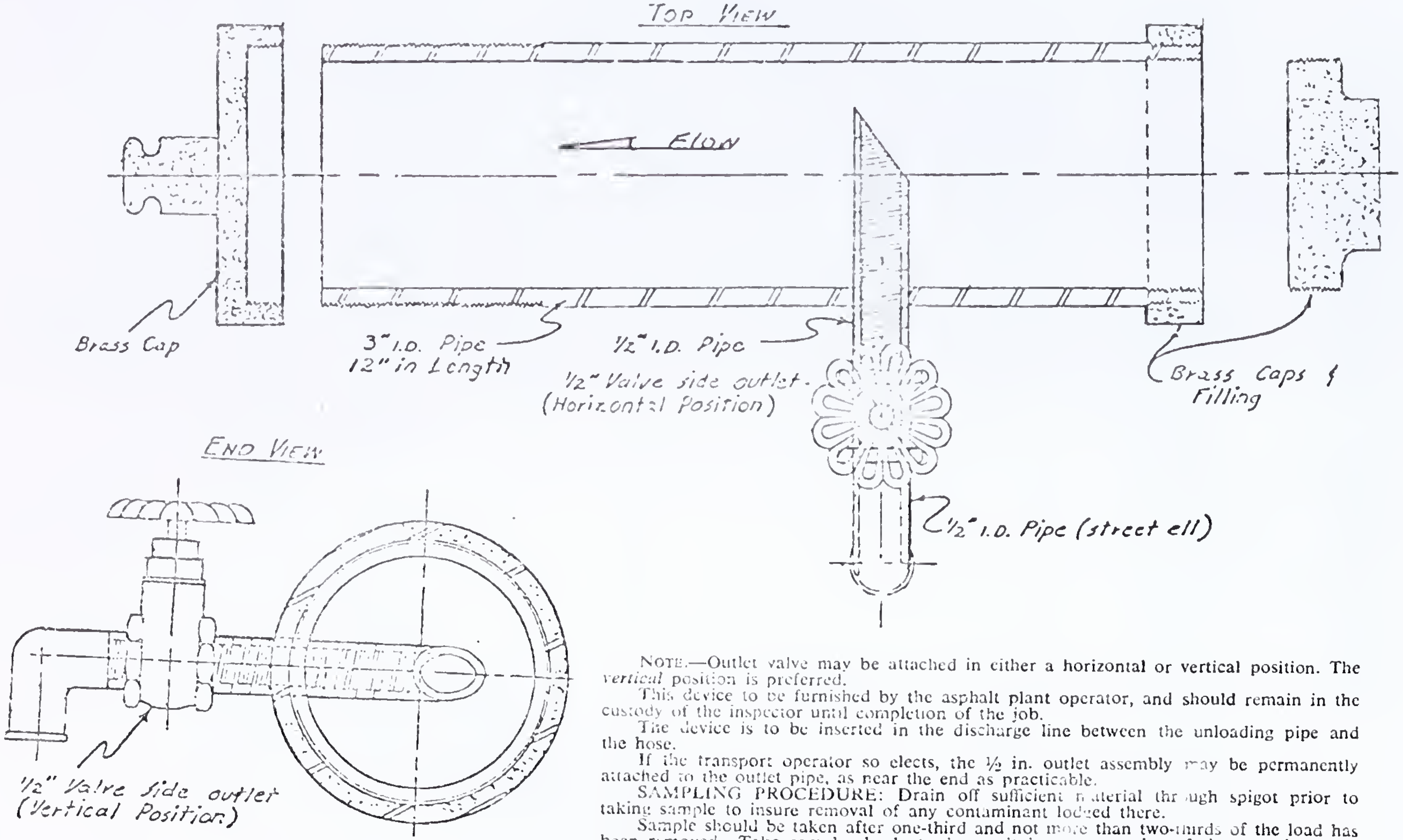


FIG. 4.—Dip Sampler.

NOTE.—Sampler with can secured in place is rapidly lowered into tank to desired depth and allowed to fill with sample. The sampler is then withdrawn from the tank and the contents transferred to the sample container. A clean container *must* be used to take each sample.



NOTE.—Outlet valve may be attached in either a horizontal or vertical position. The *vertical* position is preferred.

This device to be furnished by the asphalt plant operator, and should remain in the custody of the inspector until completion of the job.

The device is to be inserted in the discharge line between the unloading pipe and the hose.

If the transport operator so elects, the ½ in. outlet assembly may be permanently attached to the outlet pipe, as near the end as practicable.

SAMPLING PROCEDURE: Drain off sufficient material through spigot prior to taking sample to insure removal of any contaminant lodged there.

Sample should be taken after one-third and not more than two-thirds of the load has been removed. Take sample slowly to insure it is representative of the material being unloaded.

FIG. 5.—Typical Device for Sampling of Liquid Asphalt from Transports.

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 736
October 1971
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

ROSS COUNT DETERMINATION OF COATED PARTICLES IN BITUMINOUS MIXTURES

1. Scope

1.1 The intention of this test is to establish a length of mixing time per batch for the operation of an asphalt plant. The aim is the least mixing time cycle that will produce a mix in which the coarse particles are completely coated and all other specifications satisfied. This method is in accordance with AASHO Designation T 195- .

2. Apparatus

2.1 Sieves–3/8 in. and No. 4 sieves. The sieves shall conform to the Standard Specifications for Sieves for Testing Purposes (AASHO Designation: M92).

2.2 Stop Watch–For checking actual mixing time.

2.3 Therometer–Range at least 50 F to 400 F.

2.4 Sample shovel.

2.5 Sample trays.

3. Size of Sample

3.1 The amount of material required to perform the test is approximately 5 to 8 pounds.

4. Preparation of Test Samples

4.1 Permit the plant to operate at an established mixing time per batch (timed by stop watch).

4.2 Take a sample at the site of the asphalt plant from three alternate truck loads of mixture.

4.3 Sieve the sample immediately, while it is still hot, through a 3/8 in. sieve (or No. 4 sieve for material maximum 3/8 in size). Take a sample large enough to yield between 200–500 coarse particles on the 3/8 in. (or No. 4) sieve. Do not overload the sieves. If necessary sieve the sample in two or three operations. Shaking should be reduced to a minimum to prevent recoating of uncoated particles.

4.4 Very carefully examine each particle. If even a tiny speck of uncoated stone is noted, classify the particle as "partially uncoated." If completely coated, classify the particle as "completely coated."

5. Calculation

5.1 The Ross Count is computed as follows:

$$\text{Ross Count} = \frac{\text{No. of completely coated particles} \times 100}{\text{Total no. of particles}}$$

5.2 This establishes a percentage of coated coarse particles for the mixing time used in this test.

5.3 Repeated tests may be run at various mixing times to arrive at the minimum mixing time that will produce the required percentage of coating.

6. Reference

AASHO T 195

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 737
October 1971
4 Pages

Bureau of Materials, Testing & Research

Method of Test for

MEASURING THE LENGTH OF DRILLED BASE COURSE CORES

1. Scope

1.1 This method covers the procedure for determining the length of cores taken from bituminous concrete roadways.

2. Apparatus

2.1 The apparatus shall be as shown in Fig. 1, with dimensions as shown in Table 1. The apparatus shall be constructed of ½" or 5/8" plywood and shall be painted to assure that wet cores do not cause warping.

2.2 Ruler — Standard folding rule with 1/16" graduations.

3. Test Specimens

3.1 Cores used as specimens for length measurement shall be in every way representative of the pavement from which they are removed. The specimen shall be drilled with the axis normal to the surface of the pavement, and the ends shall be free from all conditions not typical of the surfaces of the pavement. Cores that show abnormal defects or that have been damaged appreciably in the drilling operation shall not be used.

4. Procedure

4.1 Measuring Total Height of Core

The specimen shall be placed in the measuring apparatus with the smooth end of the core, that is, the end that represents the upper surface of the pavement, flush with the edges of the open end of the Vee.

4.1.1 A total of eight measurements will be made on each core. Each of these eight measurements shall be read directly to 1/16 inch. (Note 1).

NOTE 1 — Each measurement is made by measuring from the core to the inside edge of the closed end of the apparatus. Four readings are taken, then the core will be rotated 90° and an additional four readings taken.

4.2 Measuring the Height of an Individual Layer

When desiring to determine the height of an individual layer the core is placed in the apparatus with one layer of the core protruding outside the edge of the Vee. The line of the layer for which a height measurement is desired will coincide with the line formed by the open end of the apparatus.

4.2.1 A total of eight measurements will be made on each core. Each of these eight measurements shall be read directly to 1/16 inch. (Note 2).

NOTE 2 – Each measurement is made by measuring from the core to the inside edge of the closed end of the apparatus. Four readings are taken, then the core will be rotated 180° and an additional four readings taken.

5. Calculation

5.1 The height of the core shall be determined by averaging the eight readings and subtracting this from Dimension C in Figure 1.

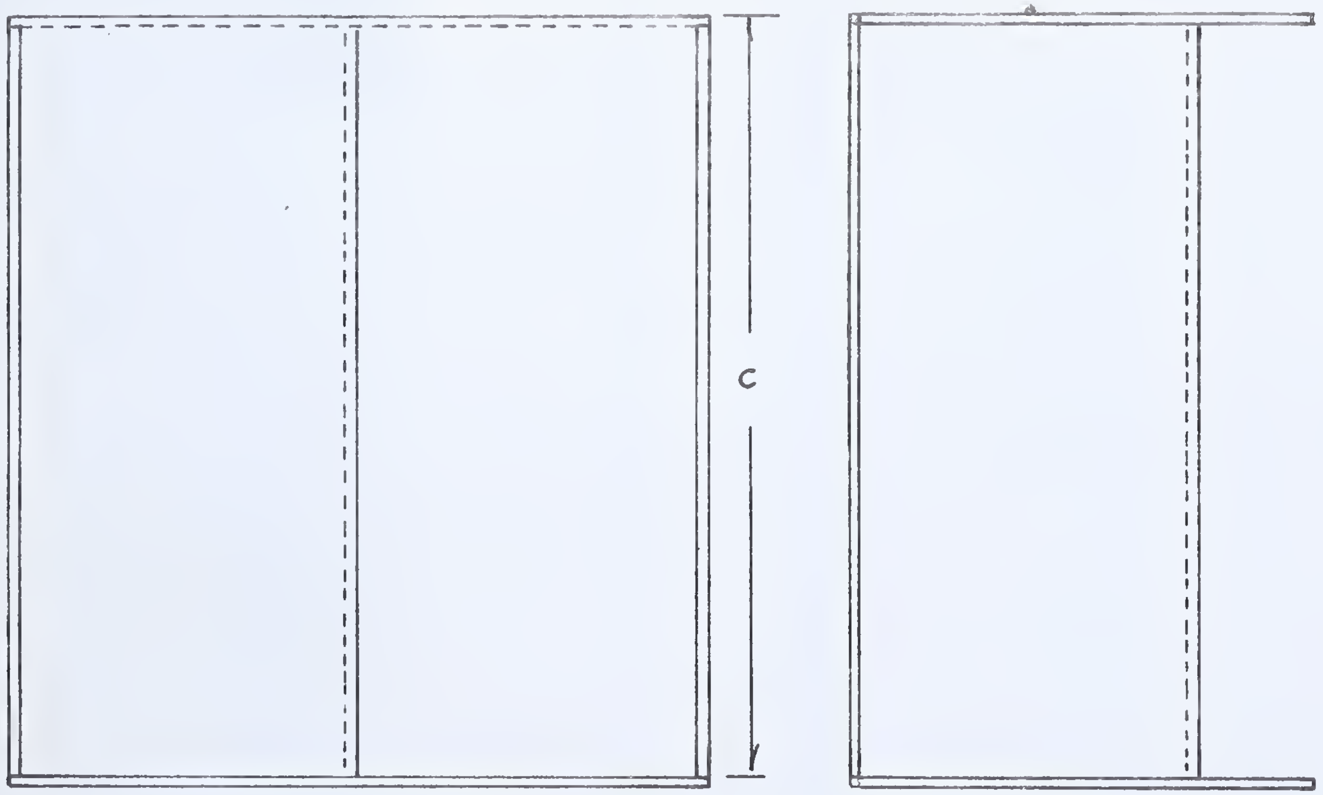
EXAMPLE: 2-3/16 N = 8 = No. of Measurements
2-2/16
2-1/16
2-4/16
2-1/16
2-3/16
2-1/16
2-1/16
16-16/16 = 17 = Sum of Individual Readings = T

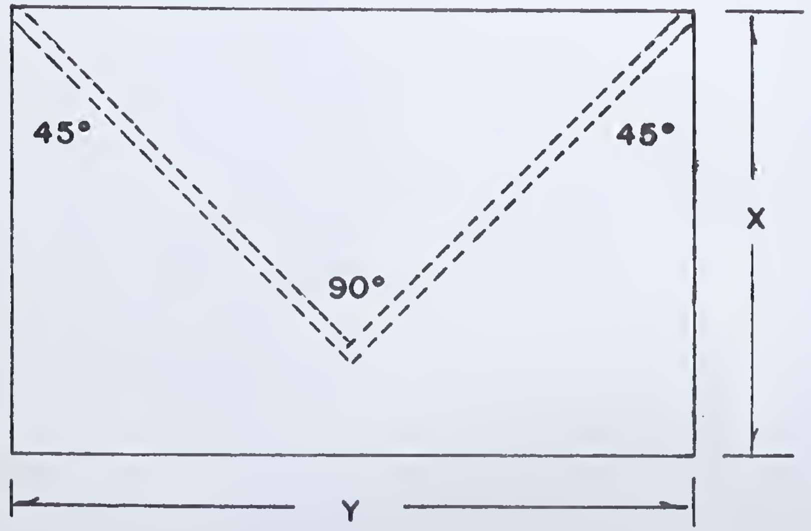
$$\frac{T}{N} = \frac{17}{8} = \text{2-1/8 Average Measurement}$$

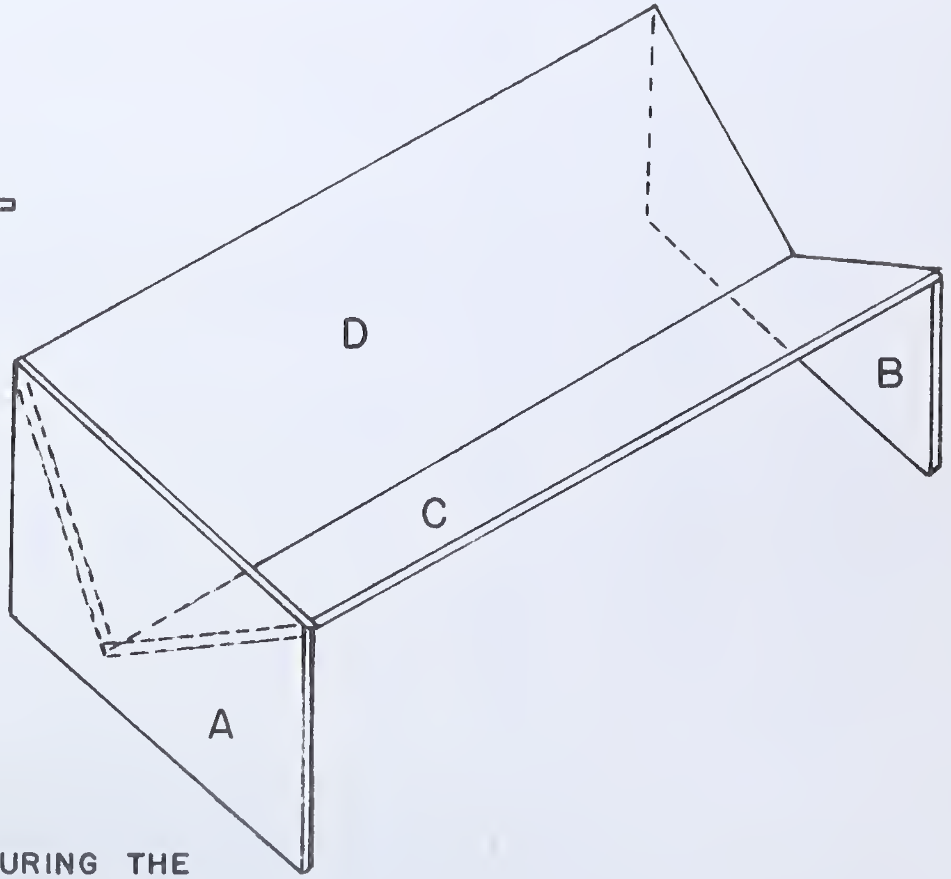
Height of Core = Dimension C - Average Reading
Height of Core = 12.0" 2-1/8"
Height of Core = 9-7/8"

6. Report

6.1 The individual observations shall be recorded to the nearest 1/16 inch, and the average of the eight measurements to the nearest 1/8 inch. The height shall be reported to the nearest 1/8 inch.







APPARATUS FOR MEASURING THE LENGTH OF BASE COURSE CORES

FIG. I

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 738
October 1971
2 Pages

Bureau of Materials, Testing & Research

Method of Test for

BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING SATURATED SURFACE-DRY SPECIMENS

1. Scope

1.1 This method of test is intended for determining the bulk specific gravity of specimens of compacted bituminous mixtures and is in accordance with ASTM D 2726-

1.2 This method of test can be used in lieu of Pa. Test Method No. 717, which has limitations on the size of the test specimens.

1.3 The bulk specific gravity of the compacted bituminous mixtures may be used in calculating the unit weight of the mixture.

2. Apparatus

2.1 Balance. A balance with sufficient capacity and a sensitivity of 0.01 percent or less of the weight of the specimen, equipped with suitable suspension apparatus and holder to permit weighing the specimen while suspended from center of scale pan of balance.

2.2 Water Bath. For immersing the specimen in water while suspended under the balance, equipped with an overflow outlet for maintaining a constant water level.

3. Test Specimens

3.1 Test specimens may be either laboratory-molded bituminous mixtures or from bituminous pavements. The mixtures may be surface or wearing course, binder or leveling course, or hot-mix base.

3.2 Size of Specimens. It is recommended, (i) that the diameter of cylindrically molded or cored specimens, or the length of the sides of sawed specimens, be at least equal to four times the maximum size of the aggregate, and (ii) that the thickness of specimens be at least one and one-half times the maximum size of the aggregate.

3.3 Pavement specimens shall be taken from pavements in accordance with Form 408, Section 401.3 (j) and PTM Nos. 729 and 730.

3.4 Care shall be taken to avoid distortion, bending or cracking of specimens during and after removal from pavements or mold. Specimens shall be stored in a safe, cool place.

3.5 Specimens shall be free from foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.

3.6 If desired, specimens may be separated from other pavement layers by sawing or other satisfactory means.

4. Procedure

4.1 For Specimens that Contain Moisture:

4.1.1 Weight of Specimen in Water — Immerse the specimen in a water bath of 77 F (25C), for 3 to 5 min, and then weigh in water. Designate this weight as C.

4.1.2 Weight of Saturated Surface-Dry Specimen in Air — Surface dry the specimen by blotting quickly with a damp towel and then weigh in air. Designate this weight as B.

4.1.3 Weight of Oven Dry Specimen — Oven dry the specimen to constant weight at approximately 230 F (110C), (15 to 24 hours is usually sufficient). Allow the specimen to cool and weigh in air. Designate this weight as A.

4.2 For Thoroughly Dry Specimens:

4.2.1 Weight of Dry Specimen in Air — Weigh the specimen after it has been standing in air at room temperature for at least 1 hr. Designate this weight as A.

4.2.2 Weight of Specimen in Water — Immerse the specimen in water bath at 77 F (25C), for 3 to 5 min, and then weigh in water. Designate this weight as C.

4.2.3 Weight of Saturated Surface-Dry Specimen in Air — Surface dry the specimen by blotting quickly with a damp towel and then weigh in air. Designate this weight as B.

5. Calculations

5.1 Calculate the bulk specific gravity of the specimen as follows:

$$\text{Bulk Sp. Gr.} = \frac{A}{B - C}$$

Where:

A = Weight of the dry specimen in air, g,
B = Weight of the saturated surface-dry specimen in air, g, and
C = Weight of the specimen in water, g.

6. Reference

ASTM D 2726

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 739
October 1971
3 Pages

Bureau of Materials, Testing & Research

Method of Test for

SIEVE ANALYSIS OF EXTRACTED AGGREGATE

1. Scope

1.1 This method of test covers a procedure for the determination of the particle size and distribution of aggregates extracted from bituminous mixtures using sieves with square openings.

2. Apparatus

2.1 Balance — Capable of weighing the total sample to an accuracy of 0.1 percent of the sample size.

2.2 Sieves — Square openings and conforming to PTM 117. Sieves shall be of various square openings and be 8 inches in diameter. They shall be available covering all sizes required by the bituminous concrete specifications.

2.3 Timer — Electric Timer shall be accurate and variable in one-minute increments with a minimum range of 15 minutes.

2.4 Mechanical Shaker — Capable of performing the sieving action as specified in Section 4.3.

3. Sample

3.1 The sample shall consist of the entire aggregate sample from PTM 702.

NOTE 1 — Where the extracted sample is too large in quantity to be sieved over one set of 8-inch sieves, the sample may be split and sieved over more than one set of 8-inch sieves and the weights on each sieve size combined for calculation of the final percent passing. In no case shall the fraction retained on any sieve at the completion of the sieving operation, weigh more than 200 g, for the 8-inch diameter sieve. The amount of material retained on the critical sieve may be regulated by the proper selection of the size of sample.

3.2 If the sample has remained at room temperature for more than one hour it shall be dried to constant weight.

4. Procedure

4.1 Record the weight of the extracted aggregate from PTM 702.

4.2 The sample shall be sieved over sieves of various sizes required by the bituminous concrete specifications. The weight of material passing each sieve and retained on the next shall be recorded, starting with the pan weight (passing the 200 mesh) and continuing up to and including the maximum size sieve.

4.3 The sieving operation shall be conducted by means of a circular motion of the sieve accompanied by jarring action to keep the sample moving continuously over the surface of the sieve. In no case shall fragments in the sample be turned or manipulated through the sieve by hand. Mechanical sieving shall be controlled by a timer and shall continue for the predetermined time. The predetermined time is established when not more than one percent by weight of the residue passes the sieve during one minute of hand sieving. Hand sieving shall be used to evaluate the thoroughness of mechanical sieving.

NOTE 2 — When mechanical shakers are used suitable sieving times are; eight minutes for all gradations except JA-1 Wearing, which requires 15 minutes.

4.4 The weight of each size aggregate shall be obtained by weighing the pan material and accumulating the weight of each increasing sieve size, (Col. A, Table 1). All sieve weights shall be accurate to within 0.1 percent of the total sample weight.

4.5 Add the weight of fine aggregate in the extract liquid as determined in PTM 702, to the weight of aggregate passing the finest sieve used in the gradation, (Col. B, Table 1), and add this weight on all sieve sizes. Record these weights in Col. C, Table 1.

NOTE 3 — The weight of fine aggregate in the extract liquid may be obtained with suitable accuracy by subtracting the total weight obtained on the maximum size sieve from the total weight of aggregate in the sample.. The total weight of aggregate in the sample is obtained by subtracting the weight of the bitumen in the sample from the total weight of the sample. This calculation assumes that all weight loss on grading is passing the 200 mesh sieve. The weight loss on grading shall be limited to 0.4 percent of the total sample.

5. Calculations

5.1 Divide the total weight of extracted aggregate into the weight of aggregate on each sieve. Record in Col. D, Table 1, percent of total sample passing each sieve. The accumulated percent of total sample passing each sieve should agree within 0.1 percent of total percentage aggregate in the bituminous concrete sample.

5.2 Divide the total accumulated percent aggregate in the sample as determined in Section 5.1, into the percent passing each sieve giving the percent of total aggregate passing each sieve (Col. E, Table 1).

6. Report

6.1 Percentages shall be reported to the nearest whole number, except for the percentages passing the No. 200 sieve which shall be reported to the nearest 0.1 percent.

GRADATION WORK SHEET

Table 1

Weight of Orig. Sample = 2173.8	Weight of Bitumen = 81.6
Weight of Extracted Sample = 2073.2	% Aggregate = 96.2
Weight of Aggregate in Extract = 19.0	% Bitumen = 3.8
Weight of Total Extracted Aggreg. = 2092.2	

Passing Sieve Size	Wt. Passing each sieve	Fines in Ext. Liq.	Total Wt. Passing each Sieve	Total % Passing	Raw Aggreg. % Passing
	A	B	C	D	E
1½	2073		2092	96.2	100.0
1	2018		2037	93.7	97.4
½	1035		1054	48.5	54.4
4	593		612	28.2	29.3
8	435		454	20.9	21.7
16	363		412	13.0	13.5
30	156		175	8.1	8.4
50	89		108	5.0	5.2
100	56		75	3.5	3.6
200	35	19	54	2.5	2.6

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 740
June, 1975
4 Pages

Bureau of Materials, Testing & Research

Method of Test for

MAXIMUM SPECIFIC GRAVITY OF BITUMINOUS PAVING MIXTURES
(Vacuum Method)

1. Scope

1.1 This method of test is intended for determining the maximum specific gravity of uncompacted bituminous paving mixtures, and is a modification of AASHTO T 209.

2. Apparatus

2.1 Balances — Balance, capable of weighing 1500 g, readable and sensitive to 0.1 g shall be used with the 1000 ml pycnometer.

Balance, capable of weighing 10 Kg, readable and sensitive to 0.5 g shall be used with the 4500 ml metal pycnometer or a 4000 ml glass pycnometer.

Balance, capable of weighing 20 Kg, readable and sensitive to 1 g shall be used with a 13,500 ml plastic pycnometer.

2.2 Container — the container may be a volumetric flask having a capacity of at least 1000 ml. For better results, vacuum pycnometers of larger capacities are recommended. See Note 1. Containers should be sufficiently strong to withstand a partial vacuum and to maintain a constant volume during handling. Construction of the pycnometer should permit clear observation of the effects of vacuum, and should facilitate shaking while under vacuum to assure bubble release. For use with the flask, a rubber stopper with a hose connection is required, whereas for use with the larger capacity pycnometers a vacuum adaptor is required. The vacuum connection assembly should consist of vacuum gauge, release valve and rubber vacuum tubing.

NOTE 1: Vacuum pycnometers recommended for use in this test method include (i) 4000 ml heavy wall Pennsylvania Pycnometer (Pyrex #5320 or Kimax #JF-5350), description and source of availability given in PTM No. 742, (ii) 4500 ml Metal Vacuum Pycnometer Model VP-7 (Pine Instrument Company, P. O. Box 429, Grove City, Pa.) and (iii) 13,500 ml Plastic Yale Pycnometer (Soil Test, Inc., 2205 Lee St., Evanston, Illinois 60202).

2.3 Vacuum Pump or Water Aspirator, for evacuating air from the container.

2.4 Constant-Temperature Water Bath, maintained at a temperature of 77 ± 0.9 F (25 ± 0.5 C).

3. Calibration of Flask

3.1 Calibrate the volumetric Flask by accurately determining the weight of water at 77 ± 0.9 F (25 ± 0.5 C), required to fill it. Accurate filling of the flask may be ensured by the use of a glass cover plate.

4. Calibration of Glass, Metal or Plastic Vacuum Pycnometer

4.1 Calibrate the pycnometer by accurately determining the weight of water at 77 ± 0.9 F (25 ± 0.5 C), required to fill it. Allow some water to overflow through capillary tube while inserting the capillary stopper. Make certain that the capillary tube is filled to the top and that no air bubbles are present after the pycnometer is kept immersed in the constant-temperature water bath for one hour.

5. Test Samples

5.1 The sample shall be obtained in accordance with PDT Methods of sampling bituminous mixtures. For design purposes, the mix shall be prepared in the laboratory. In case of some aggregates which exhibit continual asphalt absorption with time, it may be required to keep the bituminous mix in an oven at 290 F ± 5 F for at least six hours immediately after preparation.

5.2 The size of the sample shall conform to the following requirements. Samples larger than the capacity of the container may be tested a portion at a time and then the results should be combined. See Note 2.

Size of Largest Particle of Aggregate in Mixture, Inch	Minimum Sample Size, g
1	2500
3/4	2000
1/2	1500
3/8	1000
No. 4	500

NOTE 2: For effective evacuation of entrapped air the sample size should not exceed 2000 grams for 4000 ml Pennsylvania Pycnometer and 4500 ml Metal Vacuum Pycnometer, and 6000 grams for the 13,500 ml plastic Yale Pycnometer.

6. Procedure

6.1 Separate the particles of the sample, using care not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 1/4 in. If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm in an oven only until it can be so handled. Careful and complete separation of the particles in the mix is essential for fast and easy evacuation of the air from the mix.

6.2 Cool the sample to room temperature, place in the flask or pycnometer, and weigh. Designate the net weight of Sample as A. Add sufficient water at approximately 77 F (25 C) to cover the sample.

6.3 Remove the entrapped air by subjecting the contents to a partial vacuum, more than 25 inches (635 mm) mercury vacuum or less than 5 inches (125 mm) mercury absolute pressure, for 10 ± 2 minutes. See Note 3. The operating ranges are shown in the enclosed figure for the gage used. Agitate the container and contents either continuously by mechanical device or manually by vigorous shaking at intervals of about 2 minutes. The glass pycnometer should be handled on a resilient surface, such as rubber or neoprene mat, and not on hard surface to avoid impact while under vacuum. Vacuum should be applied and released gradually by using the bleed valve.

NOTE 3: Evacuation period of 5 to 8 minutes is recommended for absorptive gravel and slag aggregate (water absorption more than two percent). Actual time required within this range would depend upon the looseness of the mix and the amount of partial vacuum applied. Evacuation period should be held as minimum as possible to avoid evacuating air from the aggregate pores. To establish the optimum asphalt content, five mixtures with varying asphalt contents have to be prepared. For mixtures using absorptive aggregate, it is recommended to run PTM 740 on the mix containing the highest asphalt content. This would ensure heavier film of asphalt around the aggregate particles and thus minimize the possibility of evacuating air from the aggregate pores. The maximum specific gravity of the remaining four mixtures can then be calculated. If these precautions are not completely effective, the supplemental procedure (Section 8 of this P.T.M.) should be followed for necessary corrections.

6.4 Fill the flask with water and bring the contents to a temperature of 77 ± 0.9 F (25 ± 0.5 C) in a constant-temperature bath. Determine the weight of flask (completely filled) and contents 10 ± 1 min. after completing 6.3. In case of larger vacuum pycnometers, ensure that the capillary tube is filled to the top, and the outside of the pycnometer is wiped with a dry cloth.

7. Calculation

7.1 Calculate the specific gravity of the sample as follows:

$$\text{Specific gravity} = \frac{A}{A + D - E} \quad \text{------} \ (1)$$

Where

A = Weight of dry sample in air, grams
D = Weight of flask or pycnometer filled with water at 77 F (25 C), grams and
E = Weight of flask or pycnometer filled with water and sample at 77 F (25 C), grams.

8. Supplemented Procedure for Mixtures containing porous Aggregate not completely coated.

8.1 If the pores of the aggregates are not thoroughly sealed by a bituminous film, they may become saturated with water during the evacuation procedure. To determine if this has occurred proceed as follows after completing the procedure in accordance with 6.4. Drain water from sample. To prevent loss of fine particles, decant water through a towel held over top of container. Break several large pieces of aggregate and examine broken surfaces for wetness.

8.2 If aggregate has absorbed water, spread sample before an electric fan to remove surface moisture. Weigh at 15 min. intervals and when the loss in weight is less than 0.5 g for this interval, the sample may be considered to be dry. This procedure requires about 2 hours and should be accompanied by intermittent stirring of the sample. Conglomerations of mixture should be broken by hand. Care should be taken to prevent loss of particles of mixture.

8.3 To calculate the specific gravity of the sample, the final surface-dry weight is substituted for A in the denominator of Eq. (1).

9. Precision

9.1 The following criteria should be used for judging the acceptability of the results at a 95 percent confidence level.

9.1.1 Repeatability — Two results obtained by the same operator should not be considered suspect unless they differ by more than 0.011 unit of specific gravity.

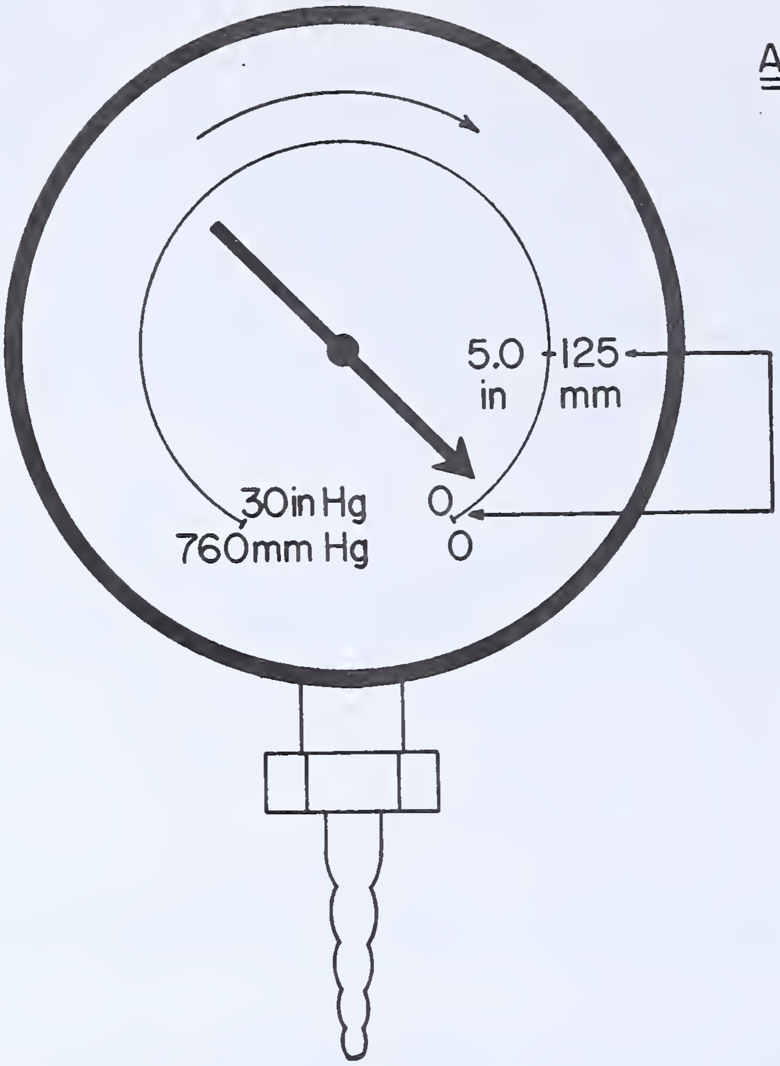
9.1.2 Reproducibility — Two results obtained by operators in different laboratories should not be considered suspect unless they differ by more than 0.019 unit of specific gravity.

9.1.3 The above criteria are not applicable to results obtained in accordance with Section 8 because of insufficient data to provide a reliable estimate of precision.

10. Reference

AASHTO T 209

ABSOLUTE PRESSURE GAGE

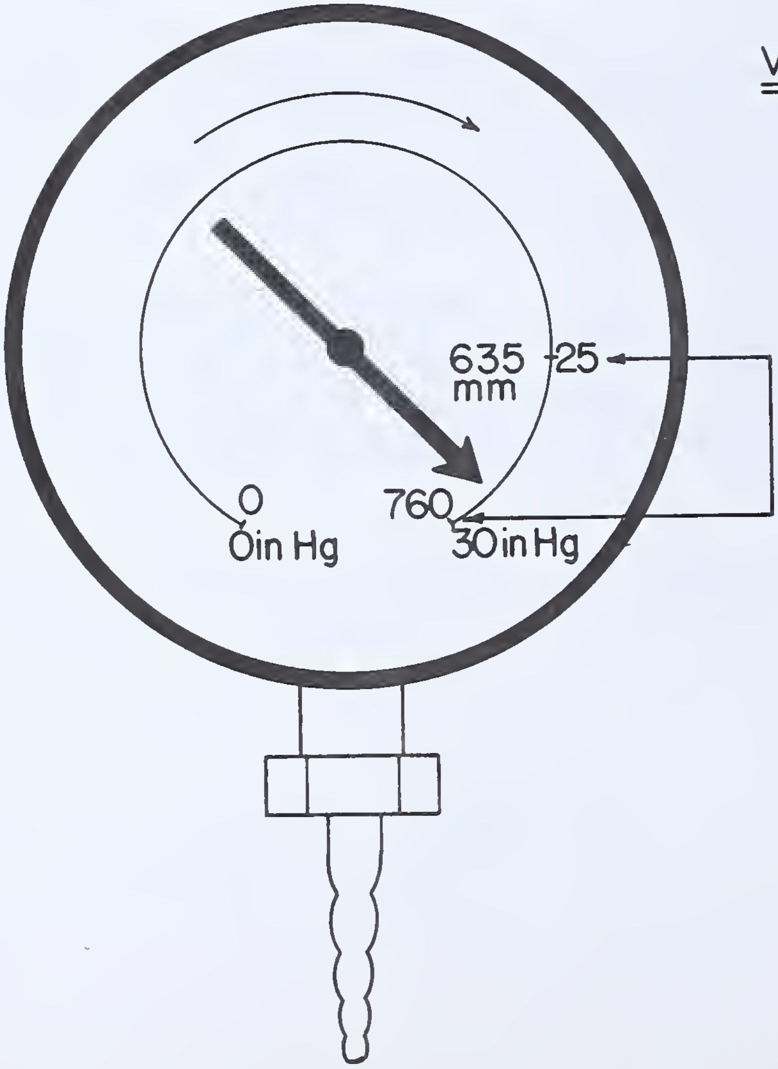


OPERATING RANGE

< 5.0 In. of Hg or

< 125 mm of Hg

VACUUM GAGE



OPERATING RANGE

> 25 In. of Hg or

> 635 mm of Hg

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 742
December 1973
10 Pages

Bureau of Materials, Testing & Research

Method of Test for

BITUMEN CONTENT OF BITUMINOUS CONCRETE MIXTURES
(Pennsylvania Pycnometer Method)

1. Scope

1.1 This method of test is intended for determining the bitumen content of bituminous concrete mixtures.

2. Apparatus

2.1 Balance — a balance sensitive to 0.1 gm at the maximum weight to be determined.

2.2 Pennsylvania Pycnometer — a 4000 ml heavy-wall glass pycnometer, fitted with a vacuum adapter, capillary stopper and overflow cap. See Table 2 and Figure 1. The pycnometer shall be sufficiently strong to withstand a partial vacuum (air pressure less than 30 mm of mercury).

2.3 Vacuum Pump or Water Aspirator for evacuating air from the pycnometer.

2 4 Dial type vacuum gage (0 to 30 inches mercury vacuum) or mercury filled absolute pressure manometer calibrated to at least 1 mm divisions.

2.5 Vacuum Trap — consisting of a 500 ml filter flask fitted with a rubber stopper.

2.6 Tubing and connectors assembly as shown in Figure 2.

2.7 Constant-Temperature Water Bath, maintained at a temperature of 77 ± 0.9 F (25 ± 0.5 C).

2.8 Thermometers, range 66 to 80 F (19 to 27 C) and 69 to 116 F (20 to 47 C) as prescribed in ASTM Specifications E-1.

3. Calibration of Pycnometer

3.1 Calibrate the pycnometer by accurately determining the weight of water at 77 ± 0.9 F (25 ± 0.5 C) required to fill it with the capillary stopper and overflow cap in place. Allow some water to overflow through the capillary tube while inserting the capillary stopper. Make certain that the capillary tube is filled to the top and that no air bubbles are present after the pycnometer is kept immersed in the constant-temperature water bath for one hour. Vacuum should be applied to remove the air bubbles, if necessary. Dry the outside of the pycnometer with an absorbent paper or cloth towel prior to weighing.

4. Test Data — the following data must be obtained to calculate the bitumen content.

4.1 Specific Gravity of bitumen (G_b) at 77 F — PTM 708.

4.2 Effective Specific Gravity of combined aggregate (G_a). This is determined by testing samples having a known bitumen content. The procedure is explained in Section 8 of this PTM.

5. Test Samples

5.1 The sample shall be obtained in accordance with PDT Methods of sampling bituminous mixtures. Inspect the sample for coating according to the requirements of PTM 736.

5.2 The size of the sample of bituminous concrete shall be from 1000 to 2000 gm. In no case should the selection of a sample of predetermined weight be attempted.

6. Procedure

6.1 Separate the particles of the sample, using care not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 1/4 inch. If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm it in an oven until it can be so handled.

6.2 Place approximately 1000 ml of water at approximately room temperature in the pycnometer to prevent asphalt stains and determine the weight of the pycnometer plus the added water. Record the weight on Line 2 of Work Sheet No. 1.

6.3 Place the warm bituminous concrete sample (See Note 2) in the pycnometer and obtain the weight of the pycnometer, water and sample. Record on Line 1 of Work Sheet No. 1.

6.4 Remove the entrapped air by subjecting the contents to a partial vacuum (more than 25 inches mercury vacuum or less than 125 mm mercury absolute pressure) for 10 ± 2 minutes. Agitate the container and contents either continuously by mechanical device or manually by vigorous shaking at intervals of about 2 minutes.

NOTE 1: The release of entrapped air may be facilitated by the addition of a suitable wetting agent such as Aerosol OT in the concentration of 0.01 percent, or 1 ml of 10 percent solution in 1000 ml of water.

6.5 Fill the flask with water. If air bubbles are caused by filling, these should be removed by means of a stirring rod or additional vacuum, if necessary. Bring the contents to a temperature between 68 F (20 C) and 100 F (37.8 C). See Note 2. Determine the weight of the pycnometer and contents (completely filled) and record on Line 9 of Work Sheet No. 1. Ensure that the capillary tube is filled to the top and that the capillary cap is in place. Dry the outside of the pycnometer prior to weighing. Immediately after weighing, measure the temperature of the water in the pycnometer and record on Line 5 within parentheses.

NOTE 2: For rapid determinations at the bituminous concrete plant, the sample from the truck should be spread in a shallow pan and allowed to cool so that the temperature of the contents in the pycnometer (mix & water) does not exceed 100 F (37.8 C). For hot mixes, chilled water can be used to obtain the temperature below 100 F (37.8 C).

7. Calculations

7.1 The maximum specific gravity of the voidless mix (G_m) is determined as follows:

$$\text{Maximum Specific Gravity } (G_m) = \frac{A}{A + D - E} \qquad \ldots\ldots\ldots (1)$$

Where:

A = weight of the mix in air
D = weight of pycnometer filled with water
E = weight of pycnometer filled with water and mix

The equation can be solved by operations in lines 1 through 12 of Work Sheet No. 1. Factors F_1 and F_2 for the corresponding test temperatures are given in Table 1. If the mixture contains porous aggregate not completely coated, follow the supplemented procedure given in Section 8 of PTM 740.

7.2 Effective specific gravity of the aggregates (G_a) shall be determined as explained in Section 8 of this PTM 708. Knowing G_a, G_b, and G_m, percent bitumen content can be determined over the range of 68 to 100 F (20.0 to 37.8 C) by operations in lines 13 and 14 of Work Sheet No. 1, or by solving the following equation:

$$P = \frac{100\, G_b}{G_a - G_b} \left[\frac{G_a}{G_m} - 1 \right] \qquad \ldots\ldots\ldots (2)$$

7.3 Knowing the values G_a, G_b and G_m, the bitumen content can also be determined by use of the attached nomograph which has been prepared to solve the Equation (2) at 77 F. This nomograph is not applicable at other temperatures. The maximum specific gravity of the mix (G_m) are connected with a straight line to (G_a). At the point where this line crosses the 1.02 Sp. Gr. of AC line, proceed horizontally to the line which is applicable to the specific gravity of the asphalt being used and read the percentage by weight of asphalt in the total mix.

8. Effective Specific Gravity of the Aggregate (G_a)

8.1 The effective specific gravity of the aggregate is determined by testing a sample of the mix which has been prepared in the laboratory with a known asphalt content (P). In order to obtain accurate results, the gradation and asphalt content of the sample must match, as closely as possible, the gradation and asphalt content of the mix being produced in the plant. The sample should be of about the same size as the samples that are tested for bitumen content.

8.2 Transfer the prepared mix to the pycnometer and determine the maximum specific gravity of the mix (G_m) in accordance with Section 7.1 of this PTM. Knowing the bitumen content (P) and the specific gravity of the bitumen (G_b), the effective specific gravity of the aggregate (G_a) can be determined by Equation (2) which has been rearranged algebraically as Equation (3) below:

$$G_a = \frac{G_m\,(100 - P)}{100 - \dfrac{G_m \times P}{G_b}} \quad \ldots\ldots \; (3)$$

This equation can be conveniently solved by operations in lines 1 through 9 on Worksheet No. 2.

8.3 At least 10 bituminous samples of known asphalt content should be tested to establish the effective specific gravity of the aggregate (G_a) for an asphalt plant. Calculate the average of the 10 determinations and then determine the maximum + and – variations from this average. If the values vary more than ± 0.010, discard these values and recalculate the average and redetermine the variation. A minimum of 6 values should be used to establish the average finally.

8.4 Testing Frequency – the specific gravity of the aggregate may change during production. The effective specific gravity (G_a) should be redetermined if the type or source of any of the aggregates being used in the mix is changed, or if the gradation of the aggregate changes enough to require a change in the job-mix formula.

NOTE 3: While transferring the mix from the mixing bowl to the pycnometer, some fine material and asphalt will stick to the bowl and spatula. This must be accounted for to determine the actual asphalt content (P) of the mix. To determine the weight of this material, determine the weight of the mixing bowl and the spatula. Wash the mixing bowl and the spatula with successive portions of solvent to dissolve the asphalt. Decant the supernatant liquid after each washing operation. When the supernatant liquid is a straw color, decant the last portion. Place the spatula and bowl in an oven to evaporate the remaining solvent. Weigh the dried bowl, spatula and aggregate fines. Difference in weight from the original is the weight of asphalt retained in the bowl and on the spatula. Remove the spatula, weigh the bowl and aggregate, wipe the dry aggregate from the bowl and weigh the empty and clean bowl. Aggregate fines are determined by difference. Weight of asphalt and aggregate fines are subtracted from the original mix weights and the percent of asphalt in the mix added to the pycnometer is recalculated on the basis of the revised weights.

9. Accuracy of Method

9.1 The bitumen content of the bituminous mixture will vary by ± 0.10 percent for the following variations in the measurements:

Weight of specimen	± 1.0 gm
Weight of displaced water	± 0.5 gm
Maximum Sp. Gr. of Mix (G_m)	± 0.003 units
Sp. Gr. of Bitumen (G_b)	± 0.010 units
Effective Sp. Gr. of Aggregate (G_a)	± 0.010 units

TABLE 1

CONVERSION FACTORS

	Factors			Factors	
Test Temp. — F	F_1	F_2	Test Temp. — F	F_1	F_2
68	1.0012	1.0018	85	0.9988	1.0042
69	1.0010	1.0019	86	0.9986	1.0044
			87	0.9984	1.0045
70	1.0009	1.0020	88	0.9982	1.0047
71	1.0008	1.0021	89	0.9981	1.0049
72	1.0007	1.0023			
73	1.0005	1.0024	90	0.9979	1.0050
74	1.0004	1.0025	91	0.9977	1.0052
			92	0.9975	1.0054
75	1.0003	1.0026	93	0.9974	1.0056
76	1.0001	1.0028	94	0.9972	1.0058
77	1.0000	1.0029			
78	0.9999	1.0031	95	0.9970	1.0060
79	0.9997	1.0032	96	0.9968	1.0062
			97	0.9966	1.0064
80	0.9996	1.0034	98	0.9964	1.0066
81	0.9994	1.0035	99	0.9962	1.0068
82	0.9992	1.0037			
83	0.9991	1.0039	100	0.9960	1.0070
84	0.9989	1.0040			

Table 2

DETAILS OF PENNSYLVANIA PYCNOMETER

A. Pennsylvania Pycnometer comprising of:

- (a) Heavy Wall Flask 4000 ml with ₮55/50 outer joint
- (b) Vacuum adaptor with ₮55 /50 inner joint
- (c) Special Overflow Cap, main part ₮55/50, inner joint; small cap ₮7/15 on top

B. Accessories for the Pycnometer:

- (a) Vacuum Gauge, 0-30 inches, 1/4 inch ips male
- (b) T-connectors, 1/4 inch, Kimble or Nalgene polypropylene (2 Nos.)
- (c) Valve to tubing connector, female, 1/4 inch ips thread brass with fiber washer
- (d) Rubber tubing, Neoprene vacuum 1/4 inch I.D., 3/16 inch wall (10 ft.)
- (e) Filter Flask, vacuum trap, 500 ml heavy wall with side tubulation
- (f) Rubber stopper, one hole, Neoprene (fusiform safety bore)
- (g) Filter pump, Aspirator 3.8 inch ips thread
- (h) Alternate for item g above:

  Welch Dist-o-pump, Model 1399 B or equivalent, Vacuum obtainable

  15 micron, 35 litres/min., 1/3 HP, 750 RPM, 115 Volts AC, 60 cycles.

C. Known Suppliers of Pennsylvania Pycnometer complete with accessories:

(a) Scientific Glass Company
735 Broad Street
Bloomfield, New Jersey 07003

(b) Kontes Glass Company
Vineland, New Jersey 08360

WORK SHEET NO. 1 (PTM No. 742)

Project No. ______________ Mix Type ______________ Producer and Location ______________ Type Aggregate ______________

Line	Sample Identification →						
1	Wt. of Mix + Pyc. + Initial Water						
2	Wt. of Pyc. + Initial Water						
3	Line 1 – Line 2 = Wt. of Mix (A)						
4	Wt. Water in Pyc. at 77 F (Calibration)						
5	Line 4 x Factor F_1 = Wt. Water in Pyc. at Test Temperature (F)						
6	Wt. Dry Pyc.						
7	Line 5 + Line 6 = :Wt. Pyc. + Water at Test Temperature						
8	Line 3 + Line 7						
9	Wt. Pyc. + Water + Mix (E)						
10	Line 8 – Line 9 = Gm Displaced Water						
11	Line 10 x Factor F_2 = cc Displaced Water						
12	Line 3 ÷ Line 11 = Max. Sp. Gr. of Mix (G_m)						
13	(G_a ÷ Line 12) – 1						
14	(J x Line 13) = % Bitumen						

G_a	Effective Sp. Gr. of Agg. (Line 9, Sheet 2) =
G_b	Sp. Gr. of Asphalt =
K	$G_a - G_b$ =
J	$(100 \times G_b) \div K$ =

Operator ______________ Date ______________

Laboratory ______________

WORK SHEET No. 2

EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE (G_a)

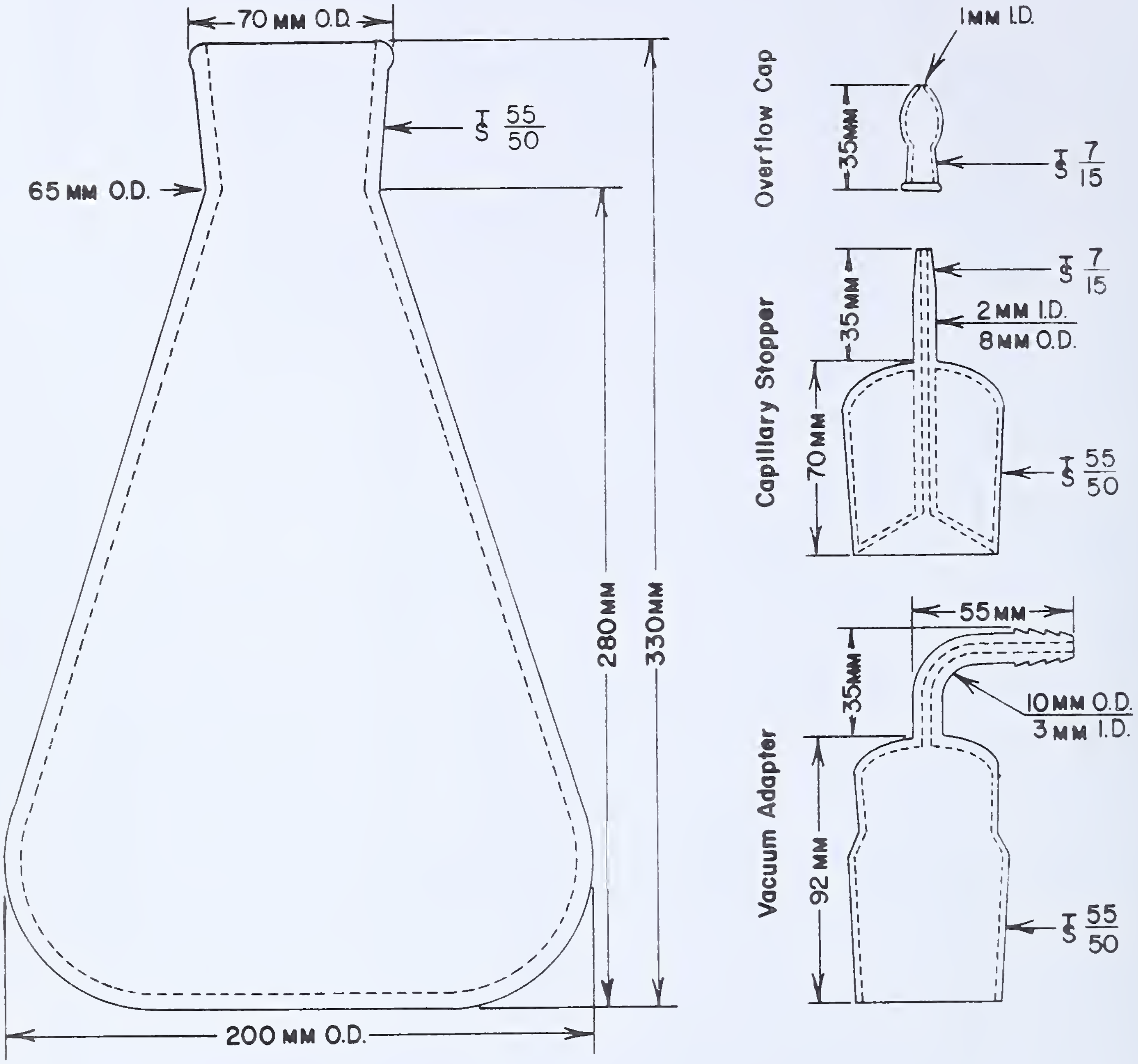
Type Aggregate ______________________ Producer ______________________

Mix Type ______________________ Plant ______________________

LINE			SAMPLE IDENTIFICATION					
1	Line 12 (G_m) of Sheet No. 1	G_m						
2	Known % bitumen	P						
3	Sp. Gr. of Bitumen	G_b						
4	Line 2 ÷ Line 3	P/G_b						
5	100.0 – Percent Bitumen	100-P						
6	Line 1 x Line 4	$(G_m \times P)G_b$						
7	Line 1 x Line 5	G_m (100-P)						
8	100.0 – Line 6	$100\text{-}G_mP/G_b$						
9	Line 7 ÷ Line 8 = Eff. Sp. Gr.	G_a						

Operator ______________________

Date ______________________



4000 ml Pycnometer, Heavy Wall

Fig. 1 Pennsylvania Pycnometer- 4000ml Capacity

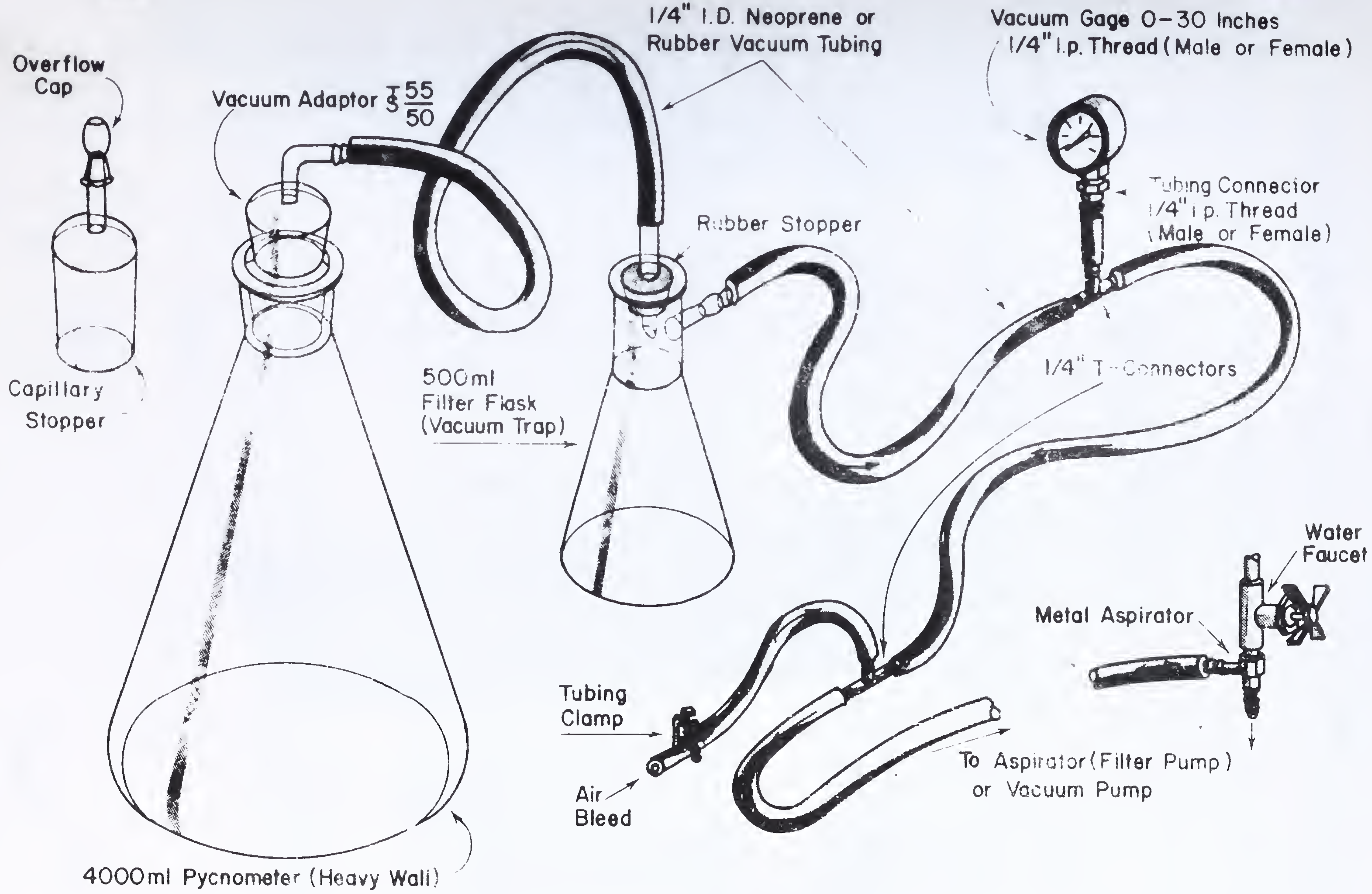

Overflow Cap
Capillary Stopper
Vacuum Adaptor 55/50
1/4" I.D. Neoprene or Rubber Vacuum Tubing
Vacuum Gage 0–30 Inches 1/4" I.p. Thread (Male or Female)
Tubing Connector 1/4" i.p. Thread (Male or Female)
Rubber Stopper
500ml Filter Flask (Vacuum Trap)
1/4" T-Connectors
4000ml Pycnometer (Heavy Wall)
Water Faucet
Metal Aspirator
Tubing Clamp
Air Bleed
To Aspirator (Filter Pump) or Vacuum Pump

Fig 2 Pennsylvania Pycnometer Assembly with Accessories

ASPHALT CONTENT

PENNSYLVANIA PYCNOMETER METHOD

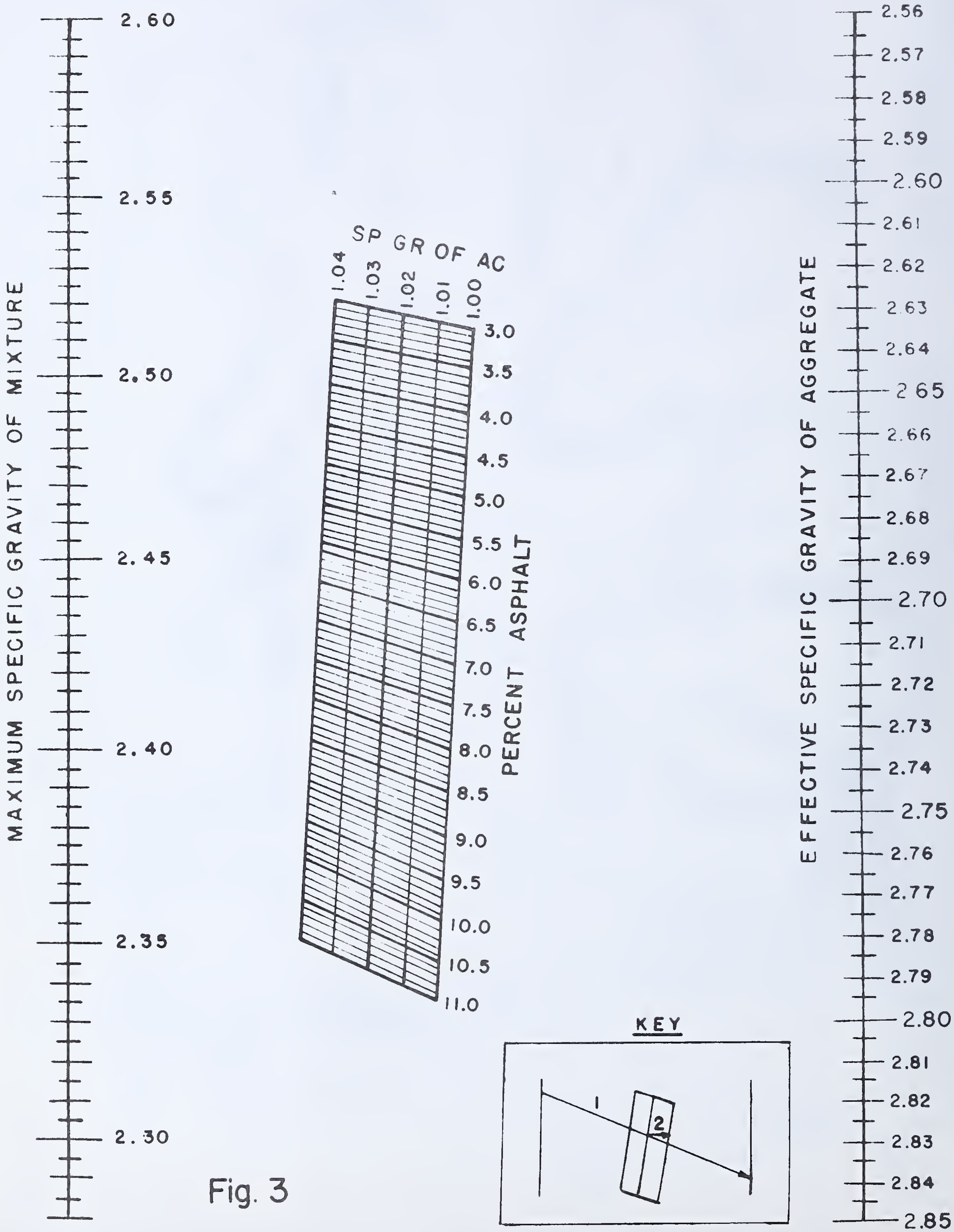


Fig. 3

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 743
September 1972
5 Pages

Bureau of Materials, Testing & Research

Method of Test for

DETERMINATION OF COMBINED GRADATION OF AGGREGATES FROM HOT BINS

1. Scope

1.1 This method of test is intended for determining the gradation of aggregates in the bituminous mixture being produced at an asphalt plant, by sampling from the hot bins.

2. Purpose

2.1 This method of test shall be used to analyze hot bin samples for quality control, and to check the uniformity of the bituminous concrete being produced to meet the approved job-mix formula.

2.2 This method of test can be used in conjunction with the PTM No. 742 in lieu of the extraction test for determining bitumen content and aggregate gradation.

3. Sampling

3.1 In the case of batch plants, the sample shall be obtained from the bin gates as the material falls into the weigh hopper. On continuous plants, the sample of aggregate shall be obtained from the feeder gates as the material is deposited on the elevator leading to the pugmill.

3.2 It is essential that sampling facilities be constructed and located so that the samples obtained will be representative of the material in the bins. In the flow of material over the plant screens, finer particles fall to the near side of the bins and coarser particles fall to the far side (Figure 1). When material is drawn from the bin by opening a gate at the bottom, the stream consists predominantly of fine material at one edge and coarse material at the other. This condition is critical in the No. 1, or fine bin, since the asphalt demand is influenced heavily by the material from this bin. Therefore, the relative position of the sampling device in the stream determines whether the sample will be composed of the fine portion, the coarse portion, or will be an accurate representation of the material in the bin.

3.3 If the asphalt plant is equipped with devices for sampling hot aggregate from the bins, it should be ensured that the device intercepts the full width of stream as shown in Figure 1. Sample device as shown in Figure 2 shall be used if the plant is not already equipped for obtaining samples from each hot bin.

4. Apparatus

4.1 Balance. The balance or scale shall be sensitive to within 0.2 percent of the weight of the sample to be tested.

4.2 Sieves. PTM 117. Mechanical sieve shakers of an approved type should be used.

4.3 Sampling device. Section 3.3 of this test method.

5. Samples

5.1 Samples for sieve analysis shall be obtained by the use of a sample splitter or by the use of quartering from the larger samples obtained from each hot bin. The sample for test shall be approximately of the weight desired and shall be the end result of the sampling method. The selection of samples of an exact predetermined weight shall not be attempted.

5.2 Samples of fine aggregate for sieve analysis shall weigh approximately as follows:

Material with at least 95 percent finer than #8 sieve	100 g
Material with at least 90 percent finer than #4 sieve and more than 5 percent coarser than # 8 sieve	500 g

NOTE 1: In no case, however, shall the fraction retained on any sieve at the completion of the sieving operation weight more than 200 g for the usual 8 in. diameter sieve. The amount of material retained on the critical sieve may be regulated by: (1) the introduction of a larger sieve, immediately above the critical sieve or (2) by the selection of a sample, of proper size.

5.3 Samples of coarse aggregate for sieve analysis shall weigh not less than an amount indicated in the following table:

Nominal Maximum Size of Particle, inch	Minimum Weight of Sample, Kg
3/8	1
1/2	2
3/4	5
1	10
1½	15
2	20

NOTE 2: For samples weighing 5 Kg or more it is recommended that sieves mounted in frames 16 in. in diameter or larger be used.

6. Procedure

6.1 The sample from each hot bin shall be separated into a series of sizes using such sieves as are necessary to determine compliance with the specifications for the material under test. The sieving operation shall be conducted by means of a lateral and vertical motion of the sieve, accompanied by jarring action so as to keep the sample moving continuously over the surface of the sieve. In no case shall fragments in the sample be turned or manipulated through the sieve by hand. Sieving shall be continued until not more than 1 percent by weight of the residue passes any sieve during 1 minute.

6.2 The weight of each size shall be determined on a scale or balance conforming to the requirements specified in 4.1. If difficulty is experienced in determining the accurate amount of minus 200 material in any of the hot bins, this can be determined by PTM #100 by washing the aggregate with water. PTM #100 may not, necessarily, be conducted daily, once a correction factor based on a series of such tests is established for an asphalt plant using the same type of aggregate. This correction factor, then, can be applied to the results of dry sieve analysis in respect to minus 200 material.

6.3 If the accumulated weight after sieving differs from the original sample weight by more than 0.5 percent, the results will be deemed unreliable and another sample will be tested.

7. Calculations

7.1 The percentage passing the given sieves shall be calculated by dividing the accumulated weights of each sieve by the total weight of sample, and shall be recorded to the nearest 0.1 percent in columns A, D, G, and J of the Aggregate Blend Form appended in this PTM.

7.2 Combined gradation of the aggregate from all the hot bins shall then be calculated on the Aggregate Blend Form according to the weight proportioning (decimal fraction of each bin in the blend) in use for the bituminous mix. This calculated combined gradation should be checked against the gradation in the Job Mix Formula.

8. References

PTM 100
PTM 117
PTM 616
PTM 742
AASHO T 11
AASHO T 27
The Asphalt Institute Manual Series No. 3

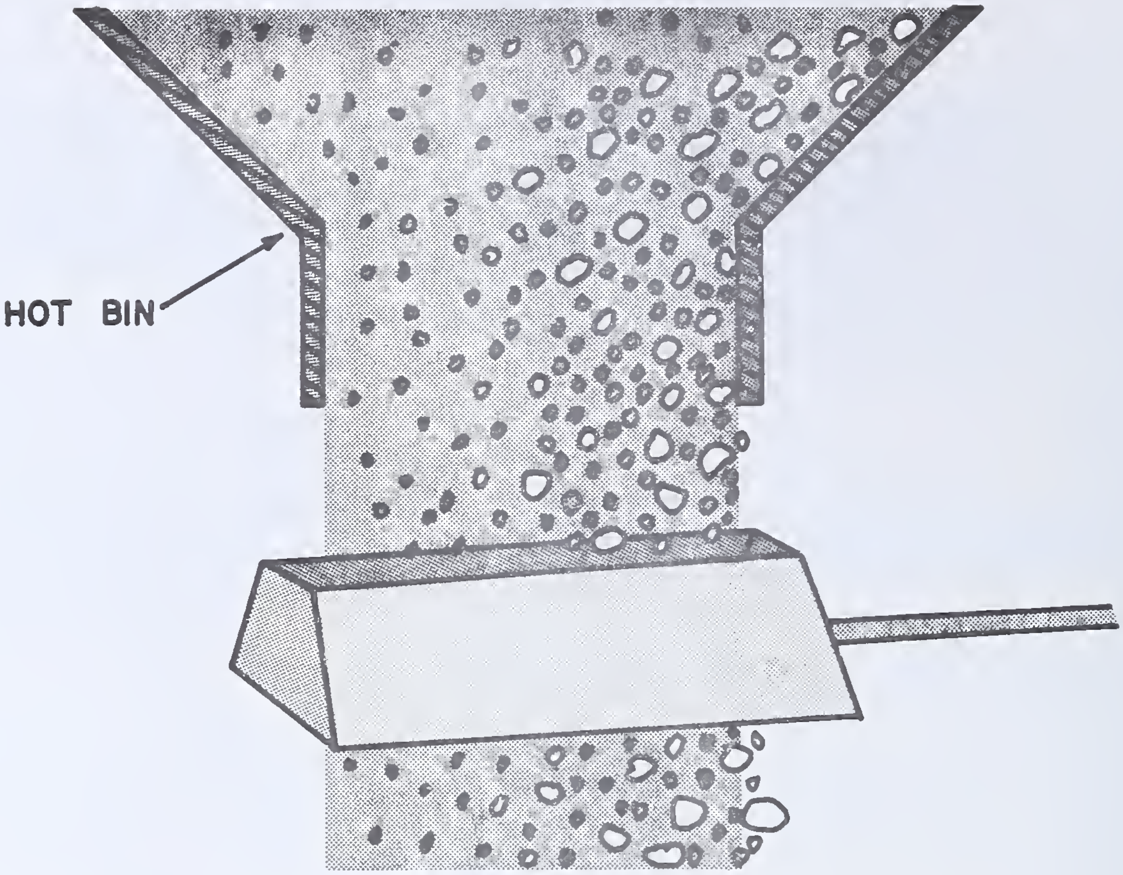


FIGURE 1 CORRECT USE OF SAMPLING DEVICE

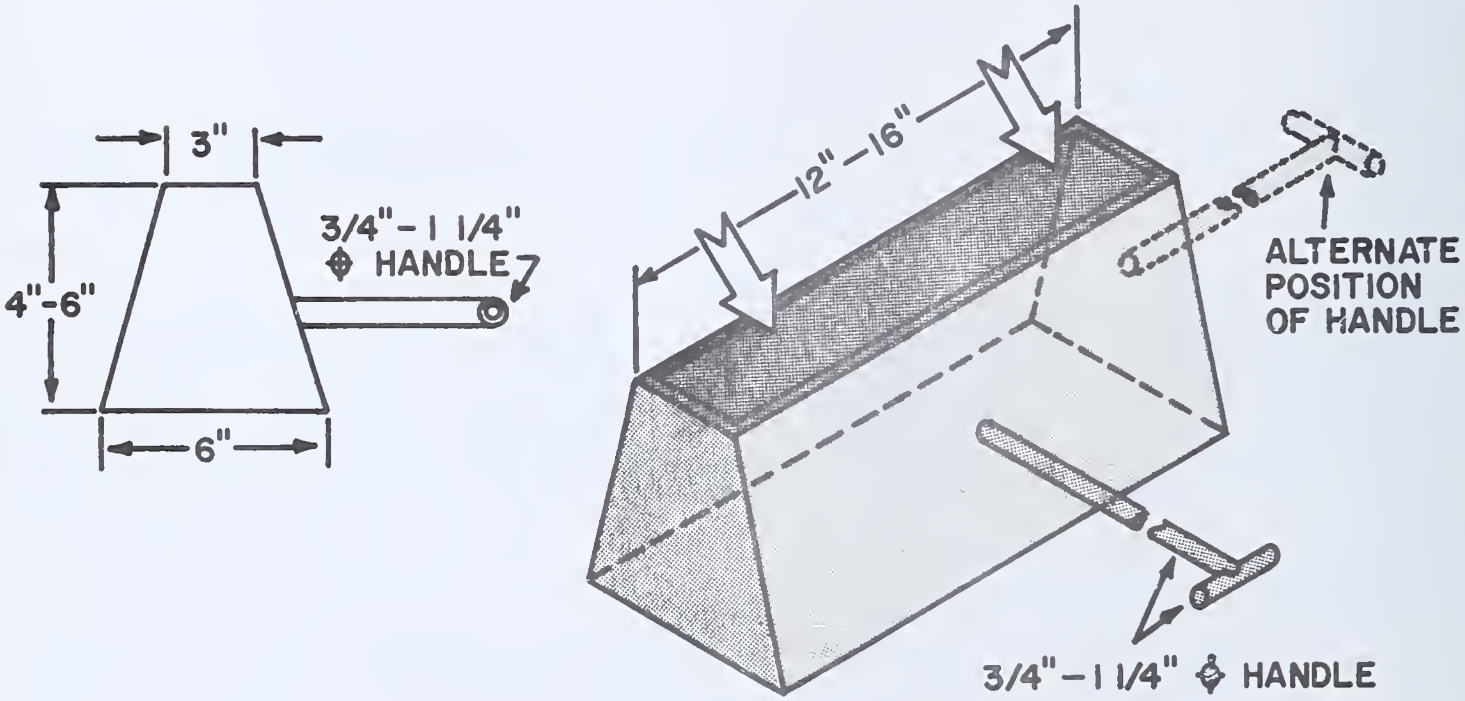


FIGURE 2 ASPHALT PLANT AGGREGATE SAMPLING DEVICE

GRADATION OF HOT-BIN AGGREGATE BLEND

SIEVE	BIN NO. 1			BIN NO. 2			BIN NO. 3			BIN NO. 4			TOTAL % PASS	
	A	x B	= C	D	x E	= F	G	x H	= I	J	x K	= L	Calc.	Design
2"														
1½"														
1"														
3/4"														
1/2"														
3/8"														
#4														
#8														
#16														
#30														
#50														
#100														
#200														

A, D, G & J = Percent Pass Each bin

B, E, H & K = Decimal fraction of each bin in the blend

C, F, I & L = Percent contribution of each bin to the final blend

Calc. = Percent passing in final blend = C + F + I + L

Design = Percent passing in the approved design

Type Bit. Conc. ____________________

Producer ____________________

Operator ____________________ Date ____________

Commonwealth of Pennsylvania
Department of Transportation

Pa. Test Method No. 746
August 1973
5 Pages

Bureau of Materials, Testing and Research

Method of Test for

SAMPLING BITUMINOUS PAVING MIXTURES

1. Scope

1.1 These methods cover the procedures for sampling mixtures of bituminous materials with mineral aggregate as prepared for use in paving. The samples shall be used for either of two purposes:

1.1.1 To represent an average of the bituminous mixture for acceptance purposes, or

1.1.2 To ascertain the periodic variations in characteristics of the mixture for the purpose of quality assurance.

2. Selection of samples

2.1 Acceptance of the bituminous mixture at the plant shall be on the basis of test results on five consecutive probability samples for each LOT. A LOT shall consist of 5 approximately equal SUBLOTS. Each SUBLOT shall be a minimum of 500 tons or a maximum of 1000 tons or one day's production. One probability sample shall be taken from each SUBLOT. It is anticipated that LOT sizes will normally be as specified. In the event that operational conditions cause work to be interrupted, or only partially completed before the LOT size specified has been achieved, the LOT may be redefined by the Engineer as being either the amount of work accomplished within the day, or combine that work within the next LOT of work.

2.1.2 Acceptance samples of the mixture shall be taken after the mixture has been discharged into hauling units using the procedure described in Section 4 of this PTM.

2.1.3 Samples shall be selected using a random number selection procedure such that all hauling units have an equal chance of being sampled. Random numbers from column X (PTM No. 1) shall be used to select the random tons to be sampled within a SUBLOT. These tons shall be obtained on multiplying the random numbers by the number of tons in a SUBLOT. The hauling units containing these random tons shall be sampled. Refer to Illustrative Example No. 1 given in the Appendix of this PTM.

2.2 Quality Assurance Sampling

2.2.1 Sampling at the place of manufacture. Three or five samples of bituminous mixture shall normally be obtained from each normal half day or full day's production respectively. Samples are to be selected by means of a stratified random sampling plan to distribute the sampling over the half day or full day, as applicable. Assume that five samples are to be taken from a normal day's production, the procedure shall be as follows:

(a) At the beginning of each day divide the anticipated period of plant operation into five approximately equal time intervals.

(b) Select a series of five consecutive two-digit random numbers from Table 2 given in PTM No. 1.

(c) To determine the sampling time, multiply the first random number in the series by the number of minutes in the first time interval and add the product to the clock time at the beginning of the interval. The load of mixture to be sampled is the first load (hauling unit) which leaves the plant following the computed sampling time.

(d) Repeat the operation, using the other four random numbers in the same order they appear in Table 2 (PTM No. 1), to determine the sampling times for the four remaining time intervals. In each case, the product of the random number and the number of minutes in the particular interval is added to the beginning clock time to determine the sampling time. Refer to Illustrative Example No. 2 in the Appendix of this PTM. Similar procedure shall be used when obtaining 3 samples from half day's production.

2.2.2 Sampling plant-mixed bituminous mixtures from roadway. For quality assurance, sample of bituminous mixtures can be obtained behind the paver prior to rolling using the procedure mentioned in Section 5 of this PTM. At least 3 samples (preferably 5 samples) shall be obtained from each LOT. A LOT shall consist of not more than 5,000 linear feet of paving lane or 6700 square yards, whichever is lesser, of each layer or course but shall not exceed one day's construction. A LOT will be subdivided into three (five, if applicable) approximately equal sublots, obtaining one sample for each SUBLOT. Samples shall be obtained on a random basis using Table 1 in PTM No. 1. The decimal values in Column X and Column Y shall be multiplied by the length and half-width of a paving land SUBLOT to obtain the coordinates of the sample location. A typical random plan for this purpose is illustrated in Example 3 given in the Appendix of this PTM.

3. Size of Samples

3.1 The size of samples shall be governed by the maximum size of particle of mineral aggregate in the mixture. The minimum size of sample shall conform to the requirements shown in Table 1.

Table 1. Size of Sample

Nominal Maximum Size of Particles Passing Sieve	Minimum Weight of Uncompacted Mixture, Lb.	Minimum area of Mix to be picked behind the paver, sq. in.
No. 8	4	36
No. 4	4	36
3/8-in.	8	36
½-in.	12	64
3/4-in.	16	100
1-in.	20	144
1½-in.	25	144
2-in.	35	225

4. Procedure for Sampling at Place of Manufacture

4.1 A high-sided scoop should be used to dig a furrow approximately 3-4 inches deep extending from the bottom to the top of the exposed pile of the mixture in the truck. The mixture should be obtained at two places in the pile approximately one-fourth from the front and rear end of the truck, each representing one half of the superficial area of the truck. The material removed in this manner will be placed on a mixing board, throughly mixed and formed into a flat pile and carefully quartered to the required size of sample.

NOTE — A convenient sampling tube for bituminous mixtures may be made by bending the sides of a round-point shovel to form a tube approximately 3½ inches in diameter.

5. Procedure for sampling behind the paver on roadway.

5.1 At predetermined random locations, the bituminous mixture should be lifted prior to compaction from an area as indicated in Table 1. It is recommended to use a steel frame 12 X 12 inches which can be placed on the pavement and the mix removed.

6. Identification of Samples

6.1 Each sample shall be accompanied by Form TR 447 for proper identification and information desired thereon.

7. References — AASHTO T 168-55 — PTM 1

APPENDIX OF PTM 746

Illustrative Example No. 1

Total tonnage of ID-2 Wearing Bituminous Mix required for the project = 12000 tons
No. of LOTS @ 4000 tons each = 3
No. of SUBLOTS in each LOT = 5
Size of a SUBLOT = 800 tons

Select a series of five random numbers for the first LOT (PTM No. 1, Table 1, Column X), and multiply by the number of tons in a SUBLOT to obtain the random tons within that SUBLOT.

Random Number		No. of Tons in SUBLOT		Ton to be sampled
0.4721	X	800	=	378 th
0.6936	X	800	=	555 th
0.6112	X	800	=	489 th
0.7930	X	800	=	634 th
0.0652	X	800	=	52 th

Therefore, the sampling sequence for the LOT (4000 tons) shall be: 378 th ton
800 + 555 = 1355 th ton
1600 + 489 = 2089 th ton
2400 + 634 = 3034 th ton
3200 + 52 = 3252 nd ton

This would mean that the hauling units containing the 378 th, 1355 th, 2089 th, 3034 th and 3252 nd tons would be sampled to obtain 5 SUBLOT samples for accepting LOT No. 1.

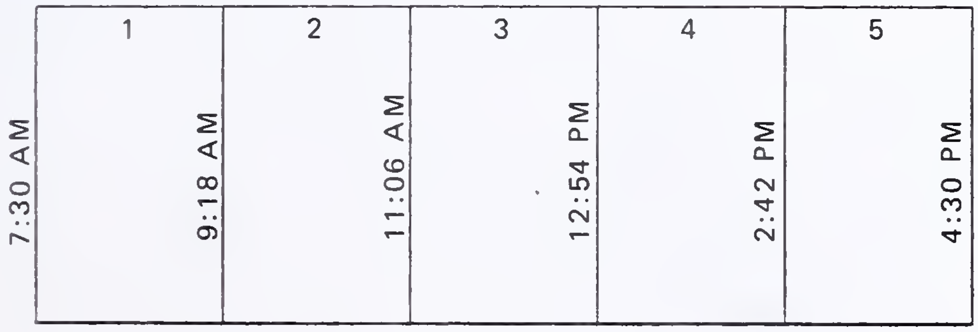
Repeat the same operation for LOTS 2 through 5 using the succeeding random numbers under Column X. Be sure to go completely through Table 1 before using the same numbers over.

Illustrative Example No. 2

Assume the plant is expected to operate nine hours, beginning at 7:30 AM, and continuing until 4:30 PM (Plants normally run continuously through lunch periods), and five samples are desired.

Divide the operating period into five intervals:

$$\text{Interval} = \frac{9\ (60)}{5} = 108 \text{ minutes}$$



Select a series of five 2-digit random numbers from Table 2 (PTM No. 1)

.54 .46 .32 .26 .62

Compute sampling times.

$.54 \times 108 = 58$
$.46 \times 108 = 50$
$.32 \times 108 = 35$
$.26 \times 108 = 28$
$.62 \times 108 = 67$

Interval		Sampling Time
1	7:30 AM + 58 minutes	8:28 AM
2	9:18 AM + 50 minutes	10:08 AM
3	11:06 AM + 35 minutes	11:41 AM
4	12:54 PM + 28 minutes	1:22 PM
5	2:42 PM + 67 minutes	3:49 PM

When it is not possible to obtain a scheduled sample because of breakdown, weather or other cause, disregard the sample and proceed to obtain the next scheduled sample. As an example, suppose a breakdown occurs at 1:00 PM and operations do not resume until 3:00 PM. In this case no sample would be obtained from interval 4 since no load left the plant between 1:22 PM, the scheduled sampling time, and 2:42 PM, the end of interval 4. Interval 5 would be sampled as scheduled.

If it becomes known that the plant will stop at 4:00 PM, a probability sample should be selected (use another random number) and taken between 2:42 and 4:00 PM.

Illustrative Example No. 3

Assume 12-foot pavement width
Length of LOT = 5000 feet (assume)
Length of SUBLOT = 1000 feet (5 SUBLOTS)

Assume beginning station is 100 + 00, therefore the sublots are:

Sublot 1	Sta. 100 + 00 to Sta. 110 + 00
Sublot 2	Sta. 110 + 00 to Sta. 120 + 00
Sublot 3	Sta. 120 + 00 to Sta. 130 + 00
Sublot 4	Sta. 130 + 00 to Sta. 140 + 00
Sublot 5	Sta. 140 + 00 to Sta. 150 + 00

Use Table 1 in PTM No. 1 to obtain random decimal fractions in X and Y Columns. These values shall be multiplied by the length and half-width of a paving lane SUBLOT behind the paver to obtain the coordinates of the sample location measured from starting point of each SUBLOT as follows:

SUBLOT 1 (Starting Station 100 + 00)

Coordinate X = 0.4721 x 1000 = 472 ft.
Coordinate Y = R 0.2091 x 6 = R 1.3 ft.
Sample Location = Sta. 100 + 00 plus 472 ft. = Sta. 104 + 72
Measure 1.3 ft. from right edge of the paving lane.

SUBLOT 2 (Starting Station 110 + 00)

Coordinate X = 0.6936 x 1000 = 694 ft.
Coordinate Y = L 0.3182 x 6 = L 1.9 ft.
Sample Location = Sta. 110 + 00 plus 694 ft. = Sta. 116 + 94
Measure 1.9 ft. from left edge of the paving lane.

SUBLOT 3 (Starting Station 120 + 00)

Coordinate X = 0.6112 x 1000 = 611 ft.
Coordinate Y = R 0.2909 x 6 = R 1.7 ft.
Sample Location = Sta. 120 + 00 plus 611 ft. = Sta. 126 + 11
Measure 1.7 ft. from right edge of the paving lane.

So on for SUBLOT 4 and 5. Be sure to go completely through Table 1 before using the same numbers over.